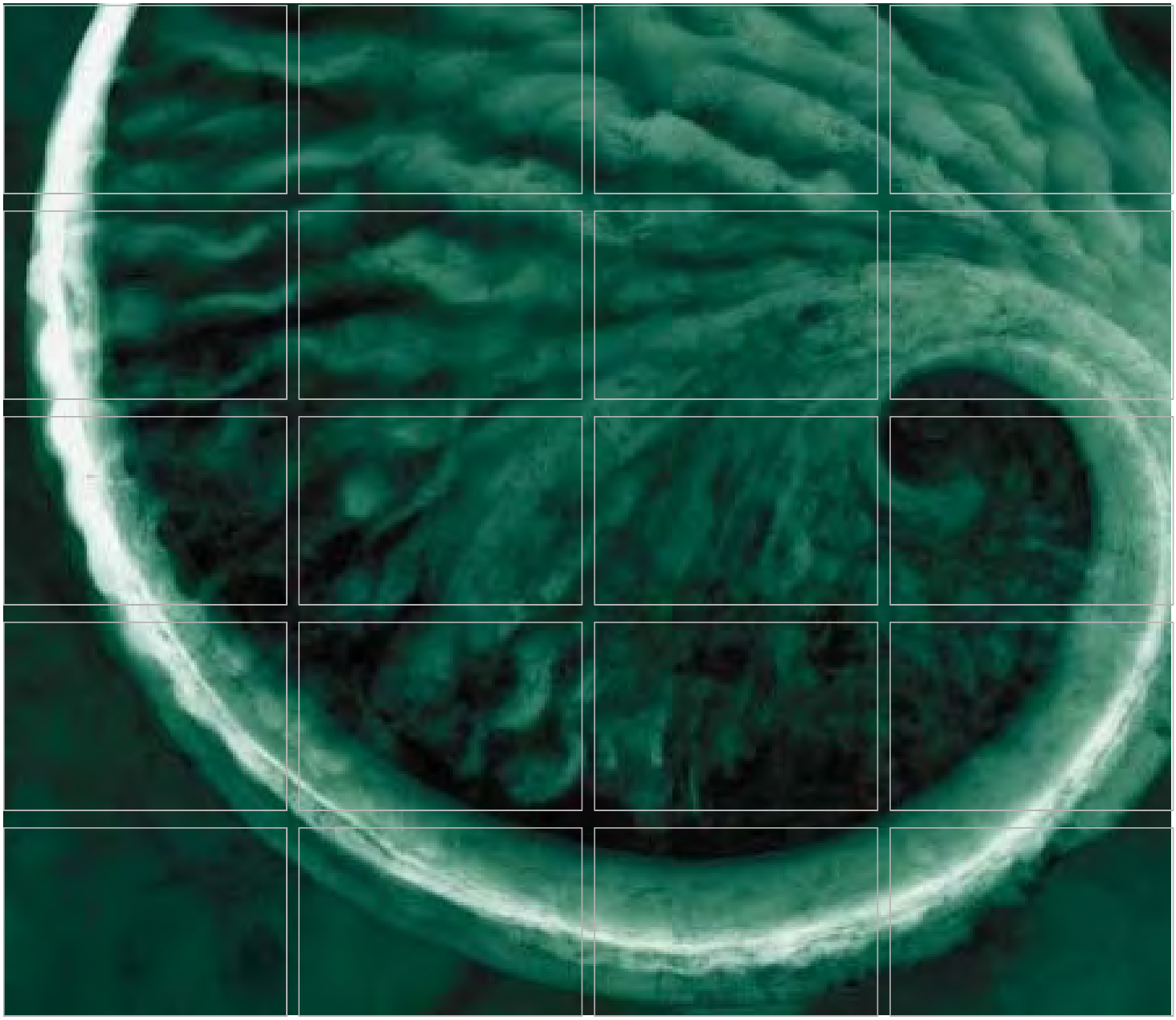
Appendix A
Field Sampling Plan



Final Field Sampling Plan OU3 Phase III Remedial Investigation and Feasibility Study

52nd Street Superfund Site Operable Unit 3 Study Area
Phoenix, Arizona

August 2010

Prepared for:
Motorola 52nd Street
Superfund Site
Operable Unit 3
Working Group

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OU3 Phase III Remedial Investigation and Feasibility Study

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Phoenix, Arizona

August 2010

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LIST OF ACRONYMS

ADEQ	Arizona Department of Environmental Quality
AOC	Administrative Order on Consent
ASGI	Active soil gas investigation
ASTM	American Society for Testing and Materials
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CRWQCB	California Regional Water Quality Control Board
COC	Contaminant of concern
EB	Equipment blank
ERM	ERM-West, Inc.
FB	Field blank
FS	Feasibility Study
FSP	Field Sampling Plan
GBRA	Groundwater Baseline Risk Assessment
IDW	Investigation-derived waste
MS/MSD	Matrix spike/matrix spike duplicate
MW	Monitoring well
NPL	National Priorities List
OU1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PE	Performance Evaluation sample
PID	Photoionization detector
PVC	Polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
SOW	Statement of Work
SV	Soil vapor
SVMW	Soil vapor monitoring well
UAA	Upper Alluvial Aquifer
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
Working Group	Motorola 52nd Street Superfund Site Operable Unit 3 Working Group, which comprises Honeywell and the Arizona Public Service Company

1.0 SITE BACKGROUND

The Motorola 52nd Street Superfund Site is located in Phoenix, Arizona (Figure 1). The site was placed on the National Priorities List (NPL) in October 1989. The site is separated into three Operable Units (OU1, OU2, and OU3). The OU3 Study Area, which is hydraulically downgradient of OU2, has been established by the United States Environmental Protection Agency (USEPA) and the Arizona Department of Environmental Quality (ADEQ) to further determine the nature and extent of groundwater contamination between 20th Street and 7th Avenue.

ERM-West, Inc. (ERM) has prepared this Field Sampling Plan (FSP) on behalf of the Motorola 52nd Street Superfund Site Operable Unit 3 Working Group (Working Group). The primary purpose of this FSP is to conduct work set forth in the Statement of Work (SOW) as required by the Administrative Order on Consent (AOC) entered into between the OU3 Working Group and the USEPA with the effective date of 23 September 2009 (USEPA 2009). The AOC was issued under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The SOW anticipates the collection of the data necessary to complete an OU3 Groundwater Remedial Investigation (RI) Report and prepare a Feasibility Study (FS) for groundwater located in the OU3 Study Area. Field work in this Phase III RI/FS will supplement prior investigations undertaken by the USEPA to assess the lateral and vertical distribution of OU3 contaminants of concern (COCs) in groundwater, defined in Section 19 of the AOC as volatile organic compounds (VOCs) including trichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and VOC degradation by-products, cis-l,2-dichloroethene, 1,1-dichloroethene, vinyl chloride, 1,1-dichloroethane, and chloroethane. The RI will also evaluate the potential for migration of COCs in groundwater into soil vapor, better define the hydrogeological parameters within the OU3 Study Area, and collect the data to conduct a groundwater baseline risk assessment (GBRA). Following completion and based on the findings of the OU3 RI Report, an OU3 FS will be prepared and implemented.

This FSP defines the sampling and data-gathering procedures that will be used to conduct the Phase III RI/FS within the OU3 Study Area. These procedures include sampling objectives, sampling locations and frequency, sample designation, sampling equipment and procedures, and sample handling and analysis. The primary purpose of the data generated under this FSP is to finalize the necessary data collection activities

necessary to prepare the OU3 RI/FS Report and a GBRA. A technical team consisting of the ERM project manager and project geologist, Working Group representatives, and hydrogeologists from the ADEQ and USEPA will use field and historical data to make final decisions on well placements, sampling intervals, and well screen depths as indicated in the RI/FS Work Plan and this FSP.

2.0 SAMPLING OBJECTIVES

Field investigations to be performed under this FSP, in conjunction with the RI/FS Work Plan, include the following activities:

- Replace a well in the Shallow Zone that can no longer be monitored due to declining water levels;
- Further delineate the extent of COCs in the southern portion of OU3 groundwater in the Shallow, Intermediate, and Deep aquifer zones;
- Further define the nature and extent of the core of the OU3 plume in the Intermediate aquifer zone;
- Quantify the vertical distribution of soil vapor concentrations due to potential off-gassing from COC-impacted groundwater;
- Collect additional hydrogeologic data from the Shallow and Intermediate aquifer zones; and
- Monitor new and existing OU3 groundwater wells.

The rationale and approach for this investigation are described in detail in the Work Plan. A brief summary of the objectives and activities included in this FSP is presented in the following subsections.

2.1 SOIL VAPOR SAMPLING

The objective of the soil vapor sampling program is to evaluate the potential of COC off-gassing from Shallow Zone groundwater. Data will be collected to establish the relationship, if any, between observed groundwater concentrations and soil vapor concentrations due to volatilization from the Shallow Zone water table surface, and attenuation of COCs in the vadose zone. Soil vapor monitoring well locations will be selected based on groundwater sampling results from the existing groundwater monitoring wells and initial sampling of the new groundwater monitoring wells. Multiport soil vapor monitoring wells will be installed near the OU3 Shallow Zone wells with the highest COC concentrations and where there are significant variations in Shallow Zone lithology (USEPA 2009). Proposed locations of the multiport soil vapor monitoring wells will be included in the Groundwater Well Installation Report, which will present the results of the first quarterly groundwater monitoring of the new groundwater monitoring wells.

2.2 SOIL SAMPLING

A limited soil sampling program will be conducted to collect various geotechnical analyses necessary to conduct the GBRA. These samples will be collected during the drilling of the soil vapor monitoring wells. Lithologic logging will also be performed during the drilling of each groundwater and soil vapor monitoring well. Soil cores from the screened intervals of the proposed groundwater and soil vapor monitoring wells will be preserved until USEPA approval of the final RI Report.

2.3 GROUNDWATER MONITORING

This FSP includes the installation of eight groundwater wells screened in the Shallow, Intermediate, and the Deep Zones of the Upper Alluvial Aquifer (UAA). The objective of the groundwater investigation will be to evaluate potential COC concentrations in three (Shallow, Intermediate, and Deep) hydrostratigraphic zones and further delineate the extent of the COCs. New wells will be monitored quarterly for 4 quarters, and existing wells will be monitored semiannually in order to provide the data necessary to fully delineate the areal extent of the COCs in all three UAA zones. Figure 2 provides a site plan illustrating existing and new OU3 groundwater monitoring well locations.

2.4 AQUIFER TEST

The aquifer testing program will be conducted to estimate hydraulic parameters of the Shallow and Intermediate hydrostratigraphic zones identified in the OU3 Study Area. These tests will be done to augment the limited data available for these hydrostratigraphic zones, and will provide estimates of the hydraulic conductivity, storage coefficient, and transmissivity. Aquifer tests will be performed after completion of the new monitoring well installations and the receipt of validated analytical data from the first round of semiannual monitoring that includes the new wells. The aquifer testing program will consist of two 12-hour constant-rate discharge tests, one in the Shallow Zone and one in the Intermediate Zone, and approximately 20 slug-type aquifer tests. The constant-rate discharge tests will be used to calculate hydraulic parameters averaged over a pumping induced cone of depression. The slug-type aquifer tests will be conducted in geographically distributed monitoring wells to evaluate the variability in hydraulic parameters within the OU3 Study Area.

The aquifer test and data analysis procedures are discussed in further detail in Section 3.5 and Section 5.0 of this FSP.

3.0 SAMPLING LOCATIONS AND FREQUENCY

This section of the FSP describes the sampling locations and frequency for the soil boring, soil vapor monitoring well, and groundwater monitoring program. Each matrix (soil, soil vapor, and groundwater) will be sampled in accordance with applicable guidance and regulations.

3.1 NEW GROUNDWATER MONITORING WELLS

There are multiple existing groundwater monitoring wells across the OU3 Site that are screened in each of the three zones; the Shallow Zone-ADEQ Hydrostratigraphic Zone S, Intermediate Zone–Hydrostratigraphic Zone M and M2, and Deep Zone–Hydrostratigraphic Zone D. ERM proposes to install seven monitoring wells that will be screened across the following units:

- Shallow Zone – four wells;
- Intermediate Zone – three wells; and

Each groundwater monitoring well will be completed within a separate borehole. The locations of the new monitoring wells were based on the OU3 SOW and shown on Figure 2. The seven new groundwater monitoring wells will be included in the site groundwater monitoring program after 4 quarterly sampling events. Section 5.5 describes the design, installation, well development, and wellhead survey procedures that will be implemented. Figures 3 and 4 provide the construction details for the monitoring wells that will be installed in the two UAA groundwater zones.

3.2 SOIL VAPOR MONITORING WELLS

Soil borings will be advanced for the installation of three soil vapor monitoring wells (SVMW). While advancing these borings, soil samples will be collected from each boring at selected depths for geotechnical analysis. Soil sample collection is discussed in Section 5.3.2.

After collection of the soil samples, SVMWs will be completed within each of the three soil borings. The SVMWs will be completed using one-half-inch polyvinyl chloride (PVC) Schedule 80 blank casing and slotted

screen. Figure 5 contains the construction details for the soil vapor monitoring wells. Screened intervals for the SVMWs will begin 10 feet above the current depth of the Shallow Zone water table.

SVMWs will be sampled per California Regional Water Quality Control Board (CRWQCB) *Interim Guidance for Active Soil Gas Investigation* (25 February 1997) and *Advisory - Active Soil Gas Investigations* (ASGI), jointly developed by Department of Toxic Substances Control and CRWQCB-Los Angeles Region (28 January 2003), on a quarterly basis for 1 year. If the first 2 quarters of soil vapor sampling show no detectable COC concentrations above detection limits provided in the Quality Assurance Project Plan (QAPP), the monitoring will be discontinued (USEPA 2009). The guidance ASGI documents are included as Appendix B.

Section 5.4 describes the SVMW design, installation procedures, sampling equipment, and purge volume test that will be conducted prior to initiating the quarterly monitoring program. Figures 5 and 6 illustrate the SVMW construction and monitoring procedures. Sections 5.4.4 and 5.4.5 describe the procedures for collecting soil vapor samples from the proposed soil vapor monitoring wells.

3.3 GROUNDWATER MONITORING PROGRAM

Groundwater monitoring of the existing OU3 groundwater wells will be performed on a semiannual basis, consistent with the previous USEPA and ADEQ sampling schedule until after the September 2010 sampling event or completion of the FS, whichever comes first. New groundwater monitoring wells will be sampled quarterly for 1 year. The collected groundwater samples will be analyzed for VOCs in groundwater by USEPA Method 8260B and for 1,4-dioxane using USEPA Method 8270C. Analytical data will be submitted in the preferred format to USEPA and ADEQ as stipulated in the ADEQ Groundwater Submittal Guidance Document (ADEQ 2005). Immediately following the installation of the new groundwater monitoring wells, the groundwater monitoring program will be initiated. Section 5.6 describes the well sampling procedures that will be implemented during each sample event. Tables 3-1 and 3-2 list the groundwater monitoring program schedule for existing and new monitoring wells.

Table 3-1 Groundwater Monitoring Program – Existing Monitoring Wells

EXISTING MONITORING WELLS	2010			
	1Q	2Q	3Q	4Q
OU3-1	X		X	
OU3-2	X		X	
OU3-4	X		X	
OU3-5	X		X	
OU3-6	X		X	
OU3-7	X		X	
OU3-8	X		X	
OU3-9	X		X	
OU3-10	X		X	
OU3-11	X		X	
OU3-12	X		X	
OU3-13	X		X	
OU3-14	X		X	
BE-MW-8	X		X	
DT-DW-5	X		X	
EW-OU3-10-S-R	X		X	
EW-13	X		X	
EW-19	X		X	
EW-20	X		X	
EW-21	X		X	
GH-MW-11	X		X	
SC-MW-1D	X		X	

Table 3-2 Groundwater Monitoring Program – New Monitoring Wells

NEW MONITORING WELLS	2010				2011			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
OU3-10A				X	X	X	X	
OU3-16A				X	X	X	X	
OU3-17A				X	X	X	X	
OU3-20A				X	X	X	X	
OU3-16B				X	X	X	X	
OU3-19B				X	X	X	X	
OU3-20B				X	X	X	X	
OU3-18D				X	X	X	X	

Notes:
Analyses: USEPA Test Method 8260B and 8270C.
Field: pH, temperature, DO, ORP and conductivity
X = Groundwater sample and water level measurements will be collected

3.4 WATER LEVEL MEASUREMENTS

Water levels will be measured in all existing and new groundwater monitoring wells. Water level measurements will be collected before each groundwater monitoring well is sampled. Section 3.3 provides a list of the OU3 wells, both current and new, scheduled for groundwater sampling and water level measurements. An electronic water level or interface probe will be used to measure the depth to groundwater. Water level measurements will be collected in conjunction with the USEPA sampling schedule. The procedures for collecting water level measurements are described in Section 5.6.

3.5 AQUIFER TESTS

Aquifer test locations will be selected after the Phase III RI monitoring well installations are completed and will be communicated to the technical team in a Technical Memorandum. The aquifer test program will

utilize existing OU3 monitoring wells as test and observation wells to the extent possible. The following criteria will be used to select the locations of the aquifer tests:

- Aquifer test well screen intervals are within the aquifer unit being tested;
- Aquifer test well screens penetrate at least 80 percent of the aquifer unit being tested;
- Constant-rate discharge tests are conducted in the central portion of the OU3 Study Area where potential remedial actions would likely be implemented;
- Slug-type test wells are located (spatially) across the OU3 Study Area;
- Observation well(s) for the constant-rate discharge tests are located no further than 100 feet from the pumping well;
- Observation well(s) screen interval is similar to the screen interval of the pumping well; and
- Aquifer test wells are outside of the influence of pumping wells such as the OU2 extraction system or local irrigation wells.

Slug tests will be performed on approximately 20 OU3 wells in both the Shallow and Intermediate Zones to estimate the horizontal hydraulic conductivity in each zone. Wells will be selected that are geographically distributed such that they show the variability of the hydraulic parameters across the OU3 Study Area.

Constant-rate discharge tests will be conducted in the Shallow and Intermediate Zones. These tests will be performed on groundwater monitoring wells located in area(s) with sufficient well density to allow for the calculation of specific yield, storativity, hydraulic conductivity transmissivity, and other aquifer parameters. Each constant-rate discharge pump test will include a step-draw down test to determine the optimum pumping rate for the test. The procedures for performing the slug-type and constant-rate discharge aquifer tests are described in Section 5.7 of this FSP.

4.0 SAMPLE DESIGNATION

Accurate and comprehensive sampling documentation will be done to create a complete record of all field procedures, including the circumstances of collection and integrity of each sample. This will also allow for detailed tracking of all samples from collection through transport and laboratory analysis, as well as facilitate the population of the OU3 database with laboratory analytical results. The following information outlines specific designation procedures that will be implemented during field investigation activities.

4.1 SAMPLE IDENTIFICATION AND LABELING

Sample identification and labeling is important for maintaining the integrity of analytical data collected during the field investigation activities. The sample identification is an integral part of the data management for future analysis of data and further investigation responsibilities, if warranted.

Each sample will have an adhesive plastic or waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label with a permanent marker at the time of collection:

- Project name;
- Sample identification;
- Date and time of sample collection;
- Preservative type (if applicable);
- Initials of sampler; and
- Laboratory analysis requested.

Along with the investigation proposed soil vapor, soil and groundwater samples, multiple Quality Control (QC) samples will be collected to measure precision and effectiveness of laboratory, decontamination and transportation procedures. The specific identification for both types of samples is described in the following sections.

4.1.1 *Soil Vapor Samples*

4.1.1.1 *Soil Vapor Monitoring Wells*

SVMWs will be uniquely identified with a sample identification that contains the sample matrix, soil vapor monitoring well number, sample port number, and date. The following is an example of the sample identification:

SV-MW-1A-022510-Q1

Soil vapor samples collected from the SVMW will be broken down as in the following example:

Matrix	Location	Well (Port)	Date	Sample
SV	MW	1A	022510	Q1

SV	Indicates a soil vapor sample
MW	Indicates the soil vapor sample is collected from a soil vapor monitoring well in the OU3 site
1A	Indicates the soil vapor monitoring well number (1, 2, etc.) and the soil vapor well port at that monitoring well: A = Shallow screened port B = Intermediate Shallow port C = Intermediate Deep port D = Deep screened port
022510	Indicates the date of the sample collection
Q1	Indicates the sample is a duplicate soil vapor sample

For example, SV-MW-1A-022509-Q1 is a duplicate soil vapor sample taken from soil vapor monitoring Well 1, Shallow screened port on 25 February 2010 at the OU3 Site.

4.1.2 *Soil Samples*

Soil samples will be collected from the proposed soil vapor monitoring wells for geotechnical analysis, and will be uniquely identified with a

sample identification that contains the SVMW number and the sample depth. The following is an example of the sample identification:

SC-SVMW-1-25-35-022510

The sample identification is broken down in the following example to describe each of the components:

Matrix	Location	Well ID	Depth Interval	Date
SC	SVMW	1	25-35	022510

SC	Indicates that the sample being collected is a soil core
SVMW	Indicates that the sample was collected at a proposed SVMW
1	Indicates the soil boring number installed during the investigation
25-35	Denotes sample collection depth, in feet below ground surface (bgs)
022510	Indicates the date of the sample collection

For example, S-SVMW-1-25-35-022510 is a soil sample taken from soil vapor monitoring well SVMW-1, from 25-35 feet bgs, on 25 February 2010 at the well location.

4.1.3 Groundwater Samples

Groundwater samples collected from the existing and proposed monitoring wells will be uniquely identified with a sample identification that contains the groundwater monitoring well number, geologic unit, date, and type of sample. The following is an example of the sample identification:

OU3-4S-S-022710-Q1

The sample identification is broken down in the following example to describe each of the components:

Well ID	Hydrostratigraphic Zone	Date	Type
OU3-4S	S	022710	Q1

OU3-4S	Indicates the OU3 groundwater monitoring well number (OU3-4S, TEW-1, etc.)
S	Denotes the hydrostratigraphic zone from which the sample was collected. For example the units could be: S = Shallow Zone M = Intermediate Zone D = Deep Zone
022710	Indicates the date of the sample collection
Q1	Indicates the sample is a duplicate water sample

For example, OU3-4S-S-022710-Q1 is a duplicate groundwater sample, taken from monitoring well OU3-4S, from the Shallow Zone on 27 February 2010 at the site.

4.1.4 *Aquifer Test Samples*

Water quality samples will be taken during aquifer testing. The aquifer test groundwater samples will be uniquely identified with a sample identification that contains the groundwater monitoring well number, geologic unit, date, time the sample is collected, and the number of samples collected during the specific aquifer test. The following is an example of the sample identification:

AT-OU3-4S-S-022710-0545-1

The sample identification is broken down in the following example to describe each of the components:

Aquifer Test	Well ID	Hydrostratigraphic Zone	Date	Time	Number
AT	OU3-4S	S	022710	0545	1

AT — Indicates that the sample is for an aquifer test

OU3-4S — Indicates the OU3 aquifer test well number (OU3-4S, TEW-1, etc.)

S — Denotes the hydrostratigraphic zone from which the sample was collected. For example the units could be:

S = Shallow Zone

M = Intermediate Zone

022710 — Indicates the date of the sample collection

0545 — Time when sample was collected

1 — Number of samples taken during aquifer test

4.1.5 *Field QA/QC Samples*

Quality Assurance/Quality Control (QA/QC) samples to be collected will include field duplicates, matrix spike/matrix spike duplicates (MS/MSD), field blanks, equipment rinsate blanks, performance evaluation samples, trip blanks, and split samples. These samples will be designated with the sample type designations listed below:

Q1 = Field duplicate sample

MS/MSD = Sample for matrix spike/matrix spike duplicate preparation

R1 = Field blank

EB = Equipment blank

Z1 = Performance evaluation sample

L1 = Trip blank

S = Split sample

Field duplicate, split, and MS/MSD samples will be identified with the matrix, boring, and depth identifiers for the parent sample with B, S, MS, or MSD as the type component. For example, SC-SVMW-1-25-35-021510-S is the split soil vapor sample collected from soil boring SVMW-1 from 25-35 feet bgs.

Field blanks will be designated with the sample matrix, R1, numbered sequentially, and identified by the date of collection. For example, the first soil vapor field blank collected on 4 September 2010 will be SV-R1-1-090410. Equipment blanks will be designated with the sample matrix, EB, numbered sequentially, and identified by the date of collection. For example, an aquifer testing equipment blank collected on 4 September 2010 will be AT-EB1-090410. Trip blanks will be identified by the sample matrix and date samples were first placed in the cooler and the cooler number. For example, GW-L1-1-012410 is the trip blank in Cooler 1 that was in use for groundwater sample storage starting on 24 January 2010. Performance evaluation samples will be designated with the sample matrix, PE, numbered sequentially, and identified by the date of collection. For example, a groundwater performance evaluation sample collected on 24 January 2010 will be GW-Z1-1-012410.

4.1.6 *Investigation-Derived Waste Samples*

Investigation-derived waste (IDW) will consist of primarily of soil and water. IDW soil may include drill cuttings and soil samples. IDW water may include: groundwater sampling purge water, decontamination water, water pumped for aquifer testing, and monitoring well development water.

Below is an example of IDW sample identification:

IDW-W-032510

The sample identification is broken down in the following example, to describe each of the components:

Sample Type	Sample Media	Date
IDW	W	032510

IDW = Investigation-derived waste sample

W = Water media

S = Soil media

032510 = Indicates date of sample

For example, IDW-W-032510 is an IDW sample taken from IDW water on 25 March 2010 at the OU3 Site. Procedures for IDW sample collection are presented in Section 5.8 of the FSP.

4.2 FIELD LOGBOOK DOCUMENTATION

Field logbooks will be the main source of field documentation for all field activities. The on-site field representative will record in the field logbook information pertinent to the investigation program. The sampling documentation will contain information on each sample collected, and will include the following information:

- Project name;
- Field personnel on-site;
- Facility visitors;
- Maps, listing of photographs taken, and/or drawings;
- Sample type and location;
- Name of sampler;
- Date and time sample collected;
- Sampling method and description of activities;
- Deviations from the QAPP and FSP; and
- Rationale for any changes to QAPP or FSP and document approval.

The books will be bound and durable to withstand adverse field conditions. All pages will be numbered consecutively. All pages will remain intact, and no page will be removed for any reason. Notes will be taken in ink. The front and inside of each field logbook will be marked with the project name, number, and logbook number. The field logbooks will be stored in the project files when not in use and upon completion of each sampling event.

At the beginning of each day, the first entry in field logbook will include the date and time, project number, names of all field personnel on-site (including subcontractors and the company for which they work), and the purpose of field work. Each subsequent page will be started with the page number and the date. The bottom of each page will have the initials of all personnel entering information onto that page. Any remaining unused lines will be crossed through. Errors will not be erased, but will have a single strikethrough. The change will be dated and initialed by the person making the change.

The following sampling forms and equipment logs will be used during the investigation process; the forms are presented in Appendix A:

- Soil Vapor Sampling Form (used during soil vapor sampling);
- Soil Boring Log (used for the lithologic description of the soil boring cuttings);
- Well Construction Diagram (used for final details for the soil vapor and groundwater monitor wells);
- Well Development Data Logs (used during the development of the proposed monitor wells);
- Groundwater Sampling Form (used during the groundwater monitoring program and sample collection);
- Aquifer Testing Forms (used during constant discharge rate and slug tests);
- Instrument Calibration Log (used for the daily field equipment calibration record keeping, if applicable);
- Daily Log (used to note daily activities onsite);
- Chain-of-Custody (used to deliver samples to lab and indicate who has possession of the analytical samples); and
- Subcontractor Production Evaluation (used to evaluate subcontractors daily activities).

4.3 CHAIN-OF-CUSTODY PROCEDURES

Chain-of-custody records are use to document sample collection and shipment to a laboratory for analysis. The chain-of-custody form is an integral component of the sampling process, and represents the permanent record of sample holding and shipment. Forms will be completed and sent with the samples for each laboratory and each shipment. If multiple coolers are sent to a single laboratory on a single day, forms will be completed and sent with each cooler. An example chain-of-custody form is presented in Appendix A.

The chain-of-custody record will identify the contents of each shipment and will document the custodial integrity of the samples. A sample is considered to be in someone's custody if it is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are delivered, the custody of the samples will be the responsibility of the ERM field representative. The chain-of-custody form will be crosschecked for errors

and signed. Corrections on paperwork will be made by placing a single line through the mistake, initialing and dating the change. The correct information will be entered above, below, or after the mistake.

When releasing samples from their custody, the ERM field representative will sign the chain-of-custody form on "relinquished by" box and note the date, time, and air bill number (if applicable). A laboratory representative will check samples with their respective chain-of-custody form(s) into the laboratory, and the form will be signed and dated appropriately. The ERM field representative or staff member will retain one copy of the signed chain-of-custody form for the project files. The original chain-of-custody form will be returned to the ERM project manager with the analytical results to go into the project files.

4.4 PHOTOGRAPHS

Photographs will be taken at areas of interest during the OU3 RI/FS investigation activities. They will serve to verify information entered in the field logbook. When a photograph is taken, the following information will be written in the logbook or will be recorded in a separate field photography log book:

- Time, date, location, and, if appropriate, weather conditions;
- Type of camera;
- Description of the subject photographed (including the photograph direction); and
- Name of person taking the photograph.

5.0 SAMPLING EQUIPMENT AND PROCEDURES

Permits are discussed in Section 5.1 and the utility clearance is described in Section 5.2. Sections 5.3 through 5.6 present the sampling procedures utilized for the collection of soil, soil vapor monitoring well, and groundwater monitoring samples. Section 5.7 details the procedures to be used to collect hydrologic information during the constant-rate pump and slug test. The IDW disposal procedures are discussed in Section 5.8. Equipment calibration is discussed in Section 5.9 and the required QC samples and procedures are described in the Section 5.10. Decontamination procedures are detailed in Section 5.11.

5.1 PERMITS

Prior to the installation of the proposed monitoring wells (Section 5.5), ERM will obtain the following permits:

- Arizona Department of Water Resources Notice of Intention to Drill Environmental Well (DWR 55-44A);
- City of Phoenix revocable right-of-way work permits, as necessary; and
- City of Phoenix-Water Services Division -Pollution Control – External Discharge Request.

5.2 UTILITY CLEARANCE AND NOTIFICATION

Most of the soil vapor and groundwater monitoring wells are located in the City of Phoenix right-of-way. These locations have numerous underground utilities, including sewers, storm drains, water mains, electric lines, fiber-optic telecommunication lines, natural gas pipelines, and above ground electric lines. Due to safety concerns associated with intrusive activities in areas with extensive underground and aboveground utilities, all utilities will be cleared prior to initiating work at the proposed locations. First, ERM will mark the proposed well locations in white paint. Arizona Blue Stake will then be contacted to notify all utilities about the intrusive work at the proposed locations. Utility companies will then locate each of their lines in the areas of intrusive activities. If numerous utilities are located in the proposed area of investigation,

ERM will contact the USEPA and the Working Group to discuss alternate location(s) of the proposed soil vapor and/or groundwater monitoring wells.

Prior to installing soil vapor and groundwater monitoring wells, each location will be air knifed to a depth of no less then 10 feet bgs to verify the absence of underground utilities. The ground surface cover (i.e. concrete or asphalt) will be removed by saw-cutting or coring and the underlying soil will be excavated utilizing air knife technology. Air knife technology utilizes high-pressure air by sending it to a focusing wand to remove the soil without disturbing the utilities. As the soil is "blown" out of the proposed well location, it is collected by a large vacuum hose and stored in a drum for use in back filling the boring location once the location is cleared. Once each location is cleared, an asphalt patch/steel trench plate will be placed over the location and labeled with the proposed well number in white spray paint. For example, if a boring is cleared, it will be marked OU3-16A-C. If unmarked utilities are encountered, ERM will notify the Working Group to discuss alternate locations for the well(s) in question. Before moving, the locations where the utilities were encountered will be backfilled and repaired according City of Phoenix specifications. ERM will then move accordingly, after consulting with the USEPA and the Working Group, until each location is clear of utilities and drilling activities can be performed.

5.3 SOIL BORING

Soil borings will be advanced using a rotosonic (sonic) drill rig at each proposed soil vapor and groundwater monitoring well location. This method alternately advances concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string will be removed with a core of drill cuttings while the outer string remains to hold the borehole open. The sonic drilling method allows for an accurate representation of the lithologic data. The following sections detail the soil boring installation and collection procedures.

5.3.1 Soil Boring Drilling and Installation

Each boring will be installed as depicted on Figure 2 using the following steps:

1. Identify the soil boring location.

2. Call Arizona Blue Stake for utility locations; double check the marks.
3. Conduct a safety briefing with the drilling operator and crew for drilling and site specific safety items.
4. Set up traffic (vehicle and pedestrian) control for the location.
5. Remove any pavement and sub-base material from area, usually a 2- by 2-foot square or twice the bit diameter. Begin air knifing procedures for underground utility clearance.
6. Once the boring location has been cleared to the desired depth (10 feet bgs), backfill the boring with the air-knifed soil cuttings and add an asphalt patch/trench plate over the boring location.
7. Before placing the drilling rig, remove the asphalt patch or trench plate from the cleared boring and place the asphalt patch in the roll-off or other approved container.
8. Place plastic sheeting on flat, level surfaces near the soil boring location and beneath the drill rig.
9. Stage well installation material in a clean secured area with appropriate access by the drilling contractor.
10. Begin drilling.
11. Record depth of sample collection (soil or groundwater) on the boring log. For soil sample collection, follow the procedures outlined in Section 5.3.2.
12. For depth-specific groundwater collection, follow the procedures outline in Section 5.5.3.
13. Rotosonic core will be retrieved by the drilling contractor and given to the geologist in 5-foot intervals on a continuous run until total depth.
14. The core will be contained in plastic sleeves, which will be placed on plastic sheeting in order of retrieval.
15. The core depth interval will be labeled on the plastic sleeve using a permanent marker and photographed.
16. The core will be field screened using a photoionization detector (PID) at approximately 5-foot intervals, until reaching the water table. PID readings will be added to the boring log.
17. Log drill cuttings will be described continuously on the boring log form(s) using the Unified Soil Classification System (USCS), per American Society for Testing and Materials (ASTM) Methods D-1452,

D-2487, and D-2488. To ensure consistency, and barring unforeseen circumstances, the same geologist will log all of the well borings as described in the following subsections.

18. After the total boring depth is reached, the drill rig will remain staged over the borehole for safety or, if moving the rig each day is required, the boring will be covered by a steel trench plate.

Once the project technical team decides on the well screen intervals, the groundwater or soil vapor monitoring well will be constructed per the procedures outlined in Section 5.4 and Section 5.5.

5.3.2 *Soil Boring Sample Collection*

The following procedures will be followed when preparing for a soil sample collection:

1. Don appropriate personal protective equipment as required by the Health and Safety Plan;
2. Place plastic sheeting on flat, level surfaces near the soil boring location, if possible. Place equipment and supplies, sampling equipment, sampling containers, and insulated cooler (if required) on separate plastic sheeting. Cover all equipment and supplies with plastic sheeting when not in use;
3. Calibrate the PID; and
4. Record all information on appropriate instrument calibration log (Appendix A). Document all changes in procedure and rationale for changes in the field logbook.

Soil samples for geotechnical analysis will be obtained at various depths bgs using either the soil core removed from the boring or by following the sampling procedures outlined below during drilling operations:

1. Install a decontaminated 18- or 24-inch-long, 2-inch-diameter, split-spoon or ring sampler on the wire-line winch or steel rods. Connect the hammer assembly and lightly tap the hammer to seal the drive shoe at the top of the undisturbed soil.
2. Mark the wire-line or steel rod in 6-inch increments from the top of the drill casing.
3. Drive the split-spoon sampler using a standard 140-pound hammer and 30-inch drop as specified by ASTM Method D-1586 or D-3550.

4. Record the number of blows, length of travel, and hammer weight required to drive the sampler in 6-inch intervals on the boring log form.
5. Cease driving when the full length of the spoon has been driven or upon refusal. Refusal occurs when little (<1 inch) or no progress is made for 50 blows of the hammer.
6. Remove the split-spoon from the boring and open.
7. Scan the length of the soil sample with the PID. Immediately place soil sample collected from the area located closest to the drive shoe in sample containers and follow any type of field preservation (if required).
8. After collecting the sample, place a sufficient amount of soil into a zip-lock-type plastic bag with adequate headspace for insertion of PID probe.
9. Label the sample bag with boring number and depth of sample, over the zip-lock portion of the bag. Record the time that the headspace was prepared.
10. Allow at least 15 minutes for volatiles to release from the soil into the void space in the sample bag. During cool weather months volatilization time may be increased to 30 minutes, or the sample may be placed in a warm environment.
11. After sufficient time has been allowed for volatilization, gently punch a hole into the sample bag using the PID probe tip. Record the highest reading obtained by the PID.
12. Record reading on the soil boring log.
13. Describe the soil samples on the boring log (lithologic log) form using the USCS. To ensure consistency, and barring unforeseen circumstances, the same geologist will log all of the soil vapor well borings.
14. Before and after each use, sample equipment, properly decontaminate steel rods and other drilling equipment to prevent cross contamination per the procedures described in Section 5.11.

An equipment list for soil sample collection activities is presented in Appendix C.

5.4 SOIL VAPOR MONITORING WELLS

After soil sample collection (Section 5.3), a nested soil vapor monitoring well will be constructed in the open borehole. At the completion of the soil boring and soil sampling the casing will remain in the borehole pending the selection of the screened interval(s). The screened intervals for the nested soil vapor monitoring well will be selected based upon the following criteria described in the SOW:

- Significant lithological variations encountered in the Shallow Zone during the drilling of existing groundwater wells in the area;
- Current and historical groundwater VOC concentrations in the Shallow Zone; and
- Consultation with the technical team.

If it is determined that a sample of groundwater from the top of the saturated zone is required, the procedures outlined in Section 5.5.3 for depth-specific groundwater collection will be followed.

5.4.1 Well Design

The soil vapor monitoring wells will be completed using one-half-inch PVC blank casing and slotted screen. A generic soil vapor monitoring well design for the casing, screen, and annular materials is presented as Figure 5 and described in Table 5-1.

Table 5-1 Soil Vapor Monitoring Well Design

Blank Casing (1/2-inch Schedule 80 PVC)	0	to	18	feet bgs
	0	to	38	feet bgs
	0	to	58	feet bgs
	0	to	78	feet bgs
0.010-inch Slotted Screen (1/2-inch Schedule 80 PVC)	18	to	20	feet bgs
	38	to	40	feet bgs
	58	to	60	feet bgs
	78	to	80	feet bgs
Cement Grout	0	to	13	feet bgs
Bentonite Seal (hydrated bentonite)	13	to	16	feet bgs
	21	to	36	feet bgs
	41	to	56	feet bgs
	61	to	76	feet bgs
Sand Filter Pack (10-20 sand)	16	to	21	feet bgs
	36	to	41	feet bgs
	56	to	61	feet bgs
	76	to	81	feet bgs

5.4.2 *Well Installation and Construction*

A geologist will provide continuous on-site supervision during the drilling, construction, and development of the proposed soil vapor monitoring wells. The well casing will be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed. Due to the small size of the proposed screen and casing, centralizers will be placed above the screened interval(s) to ensure proper spacing between nested wells. Lubricating oils and grease will not be used on casing threads. No glue of any type will be used to secure casing joints. Teflon "O" rings may also be used to ensure a tight fit and minimize leakage. Casing joints will be joined per the manufacturer's specifications. During the well installation, the casing string(s) will be hung in suspension. Final construction details of monitoring wells will be recorded on a well construction diagram (Appendix A).

5.4.2.1 *Annular Space*

The inner diameter of the sonic casing will be 6-inch nominal inner diameter to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the casing. The annular space will be approximately 2 inches.

The annular material design depths will be verified by using two methods; (1) mathematical calculation of annular space volumes and (2) a "tag-line" on the Sonic rig. To calculate the annular space volume in the borehole in cubic feet per linear foot (ft^3/Lin. ft) based on borehole diameter and casing diameter using the following equation:

$$\text{Annular Space Volume} = \pi\left[\left(\frac{D2}{2}\right)^2 - \left(\frac{d2}{2}\right)^2\right]$$

Where: D2 = borehole diameter in inches

d2 = vapor well casing diameter in inches

The second method for verifying design depths will be utilized after the annular space volume calculation. The tag-line will be dropped in the borehole between the well casing and outer casing to verify the specific depth of the annulus material as the vapor well is being constructed.

5.4.2.2 *Filter Pack*

A minimum of 6 inches of the filter pack materials will be placed under the bottom of the well screen to provide a firm footing and an unrestricted flow under the screened area. Also, the filter pack will extend a minimum of 1-foot above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. The filter pack will be installed by pouring the sand into the open drill stem. Sand filter pack will be poured in approximately 1-foot intervals to prevent bridging. Depth will be confirmed with a weighted tape.

The filter pack materials will consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain size distribution or particle sizes of the filter pack materials will be 10-12 grade. Filter pack materials will not be accepted unless proper documentation is furnished as to the composition, grain size distribution, cleaning procedure, and chemical analysis.

5.4.2.3 *Bentonite Seal*

Bentonite pellets will consist of ground, dried bentonite compacted into pellets or granules. The bentonite seal will be placed above the filter pack to isolate the screened interval for the soil vapor sampling. Pellets or granules will be placed by slowly pouring them into the annular space between the outer casing and the PVC well casing. A volume of bentonite will be placed to allow a 2-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Upon confirmation of dry bentonite placement using a weighted tape, it will be hydrated with potable water. Pellets or granules will then be placed in 2-foot lifts and hydrated to approximately 1 foot below the next vapor monitoring well port. Bentonite will be allowed to hydrate for a minimum of 30 minutes prior to construction of the next soil vapor monitoring well port.

5.4.2.4 *Cement Grout*

The annular space between the casing and the borehole wall will be filled with neat cement/bentonite grout. The neat cement grout will be mixed using 6.5 to 7 gallons of water per 94-pound bag of Type 1 Portland cement. The addition of bentonite (5 to 10 percent) to the cement grout will be used to delay the "setting" time, reduce heat of hydration, and prevent shrinking or cracking of the neat cement.

The grout will be placed into the borehole, by the tremie method, from the top of the uppermost bentonite seal to within 2 feet of the ground surface. The bentonite pellet seal or filter pack will not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal. The grout will be allowed to cure for a minimum of 12 hours before the concrete surface pad is installed.

5.4.2.5 *Concrete Surface Completion and Well Vault*

A concrete completion will be installed around the well at the same time as the flush mounted traffic-rated well vault is being installed. The completion will be formed around the well casing. The circular or square concrete completion will be poured at the surface and into the borehole (on top of the grout) in one operation making a contiguous unit. The finished completion will be slightly sloped so that drainage will flow away from the protective casing and surface completion. Although flush-mounted vaults may vary in design, the vaults will have seals that make the units water-tight when closed and secured. Permanent identification

markings will be placed on the covers or in the concrete plug around the cover. The well vaults and concrete surface completion will conform to City of Phoenix right-of-way standards, where applicable.

5.4.3 *Equipment Installation - Soil Vapor Monitoring Wells*

After the SVMW is completed, small diameter semi-ridged Teflon-lined tubing (approximately one-quarter inch outside diameter) will be installed from the surface to the base of the screened interval in the SVMW. The tubing will be used to collect soil vapor samples by attaching a sampling manifold (Figure 6) to the surface end of the tubing and purging the well volume that had the highest concentration of COC during the purge test. After a minimum of 1 week of equilibration, each SVMW will be purged and sampled simultaneously with a manifold system that monitors purge rate individually for each well (Figure 6). Prior to sampling, all tests per the ASGI guidance (Appendix B) that are outlined in Section 5.4.4 will be followed and decontamination procedures described in Section 5.11 will be completed An equipment list for collecting soil vapor samples is presented in Appendix C.

5.4.4 *Leak Test*

Soil vapor samples are susceptible to dilution from ambient air, which can produce results that underestimate actual concentrations or even contaminate the sample with external contaminants. Leak tests will therefore be conducted to verify that leakage has not occurred during sample collection. The following leak test procedures will be followed in accordance with the following ASGI recommendations:

1. Leak tests will be conducted at every soil vapor sampling location to monitor for ambient air entering the sampling system or where cross contamination may occur.
2. Leak check or "tracer" compounds will be used as leak check compounds.
3. The leak detection procedure will be conducted at each sampling location.
4. A clear Plexiglas "shroud" will be placed over the well vault (Figure 7).
5. During placement of the hood, manifolds attached to the "shroud" will be connected to the dedicated sample tubing at the wellhead.

6. Summa canisters will be connected via tubing to the "shroud" manifolds and will remain outside of the "shroud."
7. The tracer compound (isobutene) will be applied at the time the soil vapor samples are collected. If the tracer compound is detected in samples, a soil vapor leak will assume to have occurred and the sampling location will be re-sampled as described below.

If leak check compound is detected in the sample, the following procedures will be implemented:

1. The cause of the leak will be evaluated, determined, and corrected through confirmation sampling.
2. If the leak check compound is suspected or detected as a site-specific contaminant, a new leak check compound will be used.
3. If leakage is confirmed and the problem cannot be corrected, the SVMW sampling equipment will be replaced.
4. The leak check compound concentration detected in the soil gas sample will be included and discussed in the report.

5.4.4 *Purge Volume Test*

All soil vapor sampling activities will be conducted in accordance with CRWQCB, ASGI, and ADEQ guidance included in Appendix B.

Purge volume tests are recommended by the ASGI to ensure stagnant or ambient air is removed from the sampling system and to ensure samples collected are representative of subsurface conditions. The purge volume test is conducted by collecting and analyzing a sample for target compounds after the removal of appropriate purge volumes. The purge test location will be conducted on the SVMW closest to the groundwater monitoring well with the highest concentration of COCs measured from the most recent monitoring event.

The purge volume will be estimated based on a summation of the volume of (1) the sample apparatus, (2) the internal volume, and (3) the annular space around the well screen. Summa canisters will not be included in the purge volume calculation. Based on AGSI recommendations, step purge tests of 1, 3, and 7 purge volumes will be conducted at the well nearest the highest groundwater COC concentrations to determine the purge volume to be applied to the other SVMWs. Purge volume will be selected based on the following criteria:

- The purge volume that produces the highest COC concentration during the step purge tests;
- If COCs are not detected in any of the step purge tests, a default of 3 purge volumes will be extracted prior to sampling; and
- The step purge tests and purging will be conducted at the same rate soil vapor is to be sampled. Samples shall be collected at between 100 and 200 milliliters per minute to limit stripping, prevent ambient air from diluting the soil vapor samples, and to reduce the variability of purging rates.

All subsequent SVMW sampling will be conducted using the purge volume selected by this test. Soil vapor samples will not be collected if field conditions such as wet conditions or low flow conditions are encountered. Low flow conditions will be defined as the presence of a high vacuum and inability to obtain flow rates of at least 100 milliliters per minute. High vacuum will be defined as the measurement of line pressures greater than 15 inches of mercury.

Duplicate samples will be collected immediately following the collection of the original sample by using the same methodology. Duplicate samples will be collected as outlined in Sections 5.10.1 and 5.10.2.

5.4.5 *Soil Vapor Sampling*

Soil vapor samples will be collected for chemical analysis using the following sampling procedure at each wellhead:

1. Use the personal protective equipment as specified in the Health and Safety Plan.
2. Assemble decontaminated sampling equipment, sampling manifold, (Figure 6) cooler, and pump on a clean sheet of Visqueen film near the well vault.
3. Fill out identification labels for the Summa canisters for each well.
4. Open the well vault.
5. Attach the decontaminated sampling manifold to the dedicated wellhead sampling points.
6. Begin purging the calculated volume of air before sampling the point using a portable pump; adjust air flow using the attached flow meter for each sampling point.

7. Once the calculated volume of air has been purged, turn off the pump and open the valve on the Summa canister to allow the soil vapor sample to be collected. The leak test discussed in Section 5.4.4 will be performed during this step.
8. The Summa canister will have a flow restrictor placed in sequence so that the air flow entering the canister to be at or below 200 milliliters per minute.
9. Record time of sampling;
10. Once the SVMW point has been sampled, close the Summa canister valve and remove from manifold;
11. Place the Summa canister in the nearby cooler to shield it from the elements;
12. Replace the dedicated sampling equipment at each sampling point into its labeled plastic bag;
13. Once all wells have been sampled, close and lock the well vault;
14. Complete field documentation including the chain-of-custody; and
15. The disposable sampling equipment that will be subsequently used and discarded (gloves, connections, etc.) will be packaged and properly disposed.

All other equipment will be decontaminated following the procedures outlined in Section 5.11.

5.5 *NEW GROUNDWATER MONITORING WELLS*

Eight groundwater monitoring wells will be constructed in separate boreholes, as described in Section 3.3. The new monitoring wells will be included in the OU3 site groundwater monitoring program after 1 year of quarterly monitoring. The following sections describe the design, installation, and development of the wells, initial sampling, and the wellhead survey.

5.5.1 *Drilling Method*

Groundwater monitoring wells will be drilled using the rotosonic drilling method. This method alternately advances concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string will be removed with a core of drill cuttings while the outer string remains to hold the

borehole open. If flowing sands are encountered, the drill casings will be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string.

Preparation of boreholes for groundwater monitoring well installation will include the following:

1. Identify the soil boring location.
2. Call Arizona Blue Stake for utility locations; double check the marks.
3. Conduct a safety briefing with the drilling operator and crew for drilling and site specific safety items.
4. Set up traffic (vehicle and pedestrian) control for the location.
5. Remove any pavement and sub-base material from area, usually a 2- by 2-foot square or twice the bit diameter. Begin air-knifing procedures for underground utility clearance.
6. Once the boring location has been cleared to the desired depth (10 feet bgs), backfill the boring with the air-knife soil cuttings and add an asphalt patch/trench plate over the boring location.
7. Before placing the drill rig, remove the asphalt patch and place it in the roll-off or other approved container.
8. Place plastic sheeting on flat, level surfaces near the soil boring location and beneath the drill rig.
9. Stage well installation material in a clean secured area with appropriate access by the drilling contractor.
10. Begin drilling.

5.5.2 *Borehole Logging*

Soil samples will be collected continuously from the rotosonic soil boring. By using the soil samples collected from the drill cores, a geologist will design the well based on the lithologic boring log (Appendix A). The geologist will classify the soils by following the procedures listed below:

1. Don appropriate personal protective equipment as required by the Health and Safety Plan.
2. Rotosonic core will be retrieved by the drilling contractor and given to the geologist in 5-foot intervals on a continuous run until total depth.

3. The core will be contained in plastic sleeves, which will be placed on plastic sheeting in order of retrieval.
4. The core depth interval will be labeled on the plastic sleeve using a permanent marker and photographed.
5. The core will be field screened using a PID at approximately 5-foot intervals, until reaching the water table. PID readings will be added to the boring log.
6. The soil will be described on the boring log according to the USCS, per ASTM Methods D-1452, D-2487, and D-2488. To ensure consistency, and barring unforeseen circumstances, the same geologist will log all of the groundwater well borings.

5.5.3 *Depth-Specific Groundwater Sampling during Drilling*

Depth-specific groundwater sampling will be required during the drilling of the Intermediate and Deep wells. Depth-specific groundwater samples will be collected and analyzed on a 24-hour turnaround. The VOC results and the lithology will be evaluated to select the Intermediate and Deep well screen intervals.

Depth-specific groundwater sample intervals will be selected based on the lithology of the soil cores retrieved from each location and screened intervals of nearby wells completed in the target hydrostratigraphic zone. Discrete samples will be collected from the top, middle, and bottom of the design screen interval for the new wells provided in Table 5-2. Samples will be collected by driving the inner and outer casing to the top of the selected groundwater sampling interval. The inner core barrel will be removed and a 10-foot-long, 2-inch-diameter, stainless steel screen will be attached to the lead rod and sent to the depth of the sampling interval. The lead rod contains a gasket that prevents the formation from flowing into the outer casing and a screened port so that water can flow up from the screened zone. The sample will be collected by placing a submersible pump above the lead rod, inflating a packer above the pump to "isolate" the water in the zone, then purging the water from the formation to obtain a representative sample. A detailed description of the depth specific groundwater sampling procedures is provided in Appendix D.

5.5.4 *Well Design*

The selection of groundwater monitoring well screen intervals will be based on the lithology documented in the field during the borehole logging and the results of the depth-specific groundwater sample(s). In addition, the intent will be to correlate the screened interval based on the

screened intervals in previously installed groundwater wells located throughout the OU3 site. The preliminary well designs for the casing size, screen size, and annular materials for the new groundwater monitoring wells are illustrated in Figures 3 and 4, and described in Table 5-2.

Table 5-2 Groundwater Monitoring Well Designs

Shallow Zone (Figure 3)				
Blank Casing (4-inch Schedule 40 PVC)	0	to	70	feet bgs
0.020-inch Slotted Screen (4-inch Schedule 40 PVC)	70	to	120	feet bgs
Cement Bentonite Grout	0	to	64	feet bgs
Bentonite Seal	64	to	67	feet bgs
Sand Filter Pack (10-20)	67	to	121	feet bgs
Intermediate Zone (Figure 4)				
Blank Casing (4-inch Schedule 40 PVC)	0	to	190	feet
0.020-inch Slotted Screen (4-inch Schedule 40 PVC)	190	to	210	feet
Cement Bentonite Grout	0	to	183	feet
Bentonite Seal	183	to	187	feet
Sand Filter Pack (10-20)	187	to	211	feet

5.5.5 *Well Installation and Construction*

A geologist will provide continuous on-site supervision during the drilling, construction, and development of the groundwater monitoring wells. In addition, the geologist will direct the drilling contractor as to the final depths of the wells according to discussions with technical team.

5.5.5.1 *Casing Installation*

The well casings will be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers. Because the total borehole diameter in sonic drilling is larger than the inner casing diameter, particular care will be taken ensure that the well casing is placed in the center of the drill casing while placing the filter pack. Centralizers will be utilized to facilitate casing alignment during

well installation. Centralizer placement will vary for each construction based on total well depth. In general, one centralizer will be secured to the screen for every 20 feet of screened interval. No centralizers will be placed along the blank casing to prevent bridging of bentonite and cement grout. Lubricating oils or grease will not be used on casing threads. No glue of any type will be used to secure casing joints. Teflon "O" rings may also be used to ensure a tight fit and minimize leakage. Casing joints will be secured to manufacturers specifications. During the well installation, the casing string will be hung in suspension. The drilling contractor will wear clean nitrile-type gloves during the handling, assembly, and construction of the well. Final construction depths of each groundwater monitoring well will be recorded on the well construction diagram (Appendix A).

5.5.5.2 *Annular Space*

The inner diameter of the rotosonic drill stem will be an 8- or 10-inch nominal inner diameter to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the casing. The annular space will vary based on the borehole diameter.

The annular material design depths will be verified for the groundwater monitoring well in the same manner as the soil vapor monitoring well, as described in Section 5.4. Two methods will be used: (1) mathematical calculation of annular space volumes and (2) a "tag-line" on the rotosonic drill rig. To calculate the annular space volume in the borehole in cubic feet per linear foot (ft^3/Lin. ft) based on borehole diameter and casing diameter, the following equation will be used:

$$\text{Annular Space Volume} = \pi\left[\left(\frac{D2}{2}\right)^2 - \left(\frac{d2}{2}\right)^2\right]$$

Where: D2 = borehole diameter in inches

d2 = monitoring well casing diameter in inches

The second method for verifying design depths will be utilized after the annular space volume calculation. The tag-line will be dropped in the borehole between the well casing and rotosonic casing to verify the specific depth of the annulus material as the monitoring well is being constructed.

5.5.5.3 *Filter Pack*

A minimum of 6 inches of the filter pack material will be placed under the bottom of the well screen to provide a firm footing and an unrestricted flow under the screened area. Also, the filter pack will extend a minimum of 3 to 5 feet above the top of the well screen to allow for settling. The bentonite seal installed above the filter pack will isolate the screened interval from the grouting material. The filter pack will be installed by pouring the sand into the open drill stem for the shallow well. For the groundwater monitoring wells to be set at depth over 150 feet, the sand will need to be washed down a 2-inch tremie pipe placed near the depth of the proposed filter pack. Sand filter pack will be placed in approximately 5-foot intervals to prevent bridging. Depth will be confirmed with a weighted tape after each interval has been placed. Once the top of the filter pack is reached, the well will be surged, by surge block, for 10 to 15 minutes. The surging will allow for the filter pack to consolidate and establish a good connection with the surrounding aquifer, before the bentonite seal is added.

The filter pack materials will consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain size distribution or particle sizes of the filter pack materials will be 10-20 silica sand. Filter pack materials will not be accepted unless proper documentation is furnished as to the composition, grain size distribution, cleaning procedure, and chemical analysis.

5.5.5.4 *Bentonite Seal*

Bentonite pellets will consist of ground, dried bentonite compacted into pellets approximately one-quarter-inch diameter. The bentonite pellet seal will be placed above the filter pack to prevent the possibility of grout infiltration into the screened interval prior to setting. Pellets will be placed by pouring or washing slowly into the annular space between the rotosonic casing and the PVC casing. For groundwater monitoring wells having the bentonite seals set below the water table, coated bentonite pellets will be used. The coating on the pellets retards the hydration of the bentonite until it has been placed at the proper depth. A volume of pellets will be placed to allow a minimum of 3- to 5-foot-thick layer of pellets above the filter pack. Hydration may extend the height of the seal. Upon confirmation of dry pellet placement using a weighted tape, pellets will be hydrated with potable water. Pellets will be allowed to hydrate for a minimum of 45 minutes prior to grouting.

5.5.5.5 Cement Grout

The annular space between the casing and the borehole wall will be filled with neat cement/bentonite grout. The neat cement grout will be mixed using 6.5 to 7 gallons of water per 94-pound bag of Type 1 Portland cement. The addition of bentonite (5 to 10 percent) to the cement grout will be used to delay the "setting" time, reduce heat of hydration, and prevent shrinking or cracking of the neat cement.

The grout will be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2 feet of the ground surface. The bentonite pellet seal or filter pack will not be disturbed during grout placement, either by the use of a side discharge port on the tremie pipe, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal. The drilling contractor will grout approximately 120 feet per day to avoid well casing damage and possible well loss. The grout will be allowed to cure for a minimum of 12 hours before the concrete surface pad is installed.

5.5.5.6 Concrete Surface Completion and Well Vault

A concrete surface completion will be installed around each groundwater monitoring well at the same time as the flush-mounted, traffic-rated, tamper-resistant well vault is being installed. The completion will be formed around the well casing. The circular completion will be poured at the surface and into the borehole (on top of the grout) in one operation making a contiguous unit. The finished completion will be slightly sloped so that drainage will flow away from the protective casing and off of the pad, and meet the City of Phoenix right-of-way requirements. Although flush-mounted vaults may vary in design, the vaults will have seals that make the units water-tight when closed and secured. Arizona Department of Water Resources 55 numbers and well identification will be placed on the vault covers.

5.5.6 Well Development

Approximately 1 week after the groundwater monitoring well is installed, a supervised pump crew will perform well development. Well development will be conducted by bailing, swabbing, and pumping the wells.

1. The groundwater monitoring wells will be bailed of all sediment collected at the bottom during the installation process;

2. The groundwater monitoring wells will be swabbed using a small 3- to 4-inch-diameter swab; and
3. A 3- to 4-inch submersible pump will be used to pump the monitoring wells for final development and field quality parameters including temperature, pH, turbidity, and specific conductivity will be collected during this process.

Each step will be repeated until the discharge water is free of sediment and predominantly clear at the end of the pumping step.

5.5.7 Wellhead Survey

In order to obtain accurate groundwater elevation data and evaluate water quality data geographically, all existing and new groundwater monitoring wells identified for groundwater monitoring will be surveyed to a consistent datum. An Arizona-registered surveyor, under supervision of a responsible field representative, will perform the surveying. The surveyor will use State Plane North American Datum 1983 (NAD 83) Arizona Central, in feet, for a coordinate system.

A series of control points or monuments will be established for use in surveying the locations of soil vapor and groundwater monitoring wells. The majority of control points will consist of permanent features, but installation of monuments may be necessary. To determine accurate groundwater elevations, the necessary precision for vertical survey coordinates of monitoring wells will be 0.01 foot.

Prior to the wellhead survey, permanent markings will be applied to the well monument and casing/sounding port to provide reference points for both the surveyors and to enable consistent future measurements. Soil vapor and groundwater monitoring wells will be surveyed for their horizontal location and vertical elevations will be determined at three points. The top of the monitoring well vault, top of the well casing or sounding port, and the ground surface will be surveyed for vertical elevation at each well and designated as the well monument. The ground surface will preferably be surveyed at the northern side of the well, but can be modified if the surface is uneven relative to the well.

5.6 GROUNDWATER MONITORING PROGRAM

This section describes the standard operating procedures that will be followed during monitor well purging and sampling. These procedures were developed in accordance with *A Compendium of Superfund Field Operations Methods* (USEPA 1987) and *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers* (USEPA 2002).

5.6.1 Water Level Measurements

Water level measurements will be collected quarterly from the new groundwater monitoring wells and before each monitoring well is sampled. The existing groundwater monitoring wells will be gauged prior to each semi-annual sampling event. All water levels will be collected within a 48-hour period. Section 3.4 lists the wells currently scheduled for groundwater sampling and water level measurements. A site-specific electronic water level and/or interface probe will be used to measure the groundwater levels. Depths to water will be measured from the surveyed measuring point on the well casing to the nearest 0.01 foot. The water level measurement will be made a minimum of two times, until two consecutive readings are within 0.01 foot of each other. The groundwater elevation data and time of measurement will be recorded in the field logbook and water level measurement field form. The data will also be entered in the project database. Water level measurement equipment will be decontaminated between measurements using procedures outlined in Section 5.11.

5.6.2 Groundwater Monitoring Well Purging

All new and existing monitoring wells will be purged using a portable submersible pump to remove stagnant water from the groundwater monitoring well and obtain representative water from the geologic formation being sampled, while minimizing disturbance to the samples. Before a sample is taken, each groundwater monitoring well will be purged until a minimum of three well volumes has been removed and field parameters (temperature, pH, and conductivity) have stabilized, or until the groundwater monitoring well is pumped or bailed dry. If the groundwater monitoring well is purged dry, that well will be allowed to recover prior to sampling. All groundwater monitoring wells will be sampled within 24 hours of purging. Purged well water will be managed as outlined Section 5.8. The following well purging procedures will be performed at each groundwater monitoring well:

1. Use personal protective equipment as specified in the Health and Safety Plan.
2. Calibrate all necessary equipment daily and record calibration information in the instrument calibration log (Appendix A).
3. Note the condition of the outer well casing, concrete well pad, protective posts (if present), and any unusual conditions of the area around the well in the field notebook. The well may also be photographed. Number all photographs and include the camera type, a description of the subject, the direction the photographer is facing, and the photographer's initials.
4. Note the condition of the inner well cap and casing and record in the field notebook.
5. Monitor the headspace of the groundwater monitoring well at the rim of the inner casing for VOCs with a PID, and record in the field notebook. If the existing groundwater monitoring well has a history of positive readings of the headspace, or if positive readings are recorded, refer to the procedure given in the Health and Safety Plan.
6. Identify the measuring point (e.g., mark on northern side, top of PVC well casing).
7. Measure and record the depth of the static water level with an electronic water-level indicator or interface probe (to nearest 0.01 foot) from the marked survey measuring point on the well casing and record the time. Note the type of the water-level indicator or interface probe used daily. The measurement will be made at a minimum of two times, until two consecutive readings are within 0.01 foot of each other. The total depth of the groundwater monitoring well will be measured before the sampling event begins. Recording well depths will measure the height of material in the well sump, which may give an indication of the integrity of the well screen. Record these data on the groundwater sampling form. An example of the groundwater sampling form is shown in Appendix A.
8. A copy of the groundwater sampling form from the previous sampling events will be available on site for reference. Review the previous purge history on the groundwater-sampling log recorded prior to purging the well. Recalculate the volume of water in the groundwater monitoring well casing in gallons based on feet of water and casing diameter as necessary:

Calculate the casing unit volume using the following equation:

$$\text{Casing Unit Volume (gallons)} = 0.041(\Phi_{in})^2\ (\Delta\ h_{ft})$$

Where:

Φ_{in} = well casing diameter in inches
$\Delta\ h_{ft}$ = (well depth in feet) - (depth to water in feet)
0.041 = conversion factor;

9. Place a portable submersible pump in the lower portion of the wetted screen interval. Double check the previous sampling event for the depth of pump placement and adjust, if needed, according to current water level. Note the adjustment and reasons for making the adjustment to the pump depth on the purge form.

10. Connect the discharge line from the submersible pump to a flow-through cell. Install a "T" connection prior to the flow-through cell to allow for the collection of water for the temperature, pH, and conductivity measurements. Direct the discharge line from the flow-through cell to a container to contain the purge water during the sampling of the groundwater monitoring well.

11. Well Purging - Start pumping the groundwater monitoring well at a measurable flow rate and slowly increase the speed. Water level measurements will be taken at selected intervals. Observation of the amount of drawdown during purging will determine the maximum purge rate such that the well will not be pumped dry. The maximum purge rate will vary for each well and will be noted on the groundwater sampling log. This procedure will be used to obtain the target purge rate to be used in subsequent sampling rounds. If a purge rate cannot be sustained and the well is pumped dry, see Procedure 17. This information will be noted in the groundwater sampling log.

12. Obtain an initial sample from the purge pump for field measurements of temperature, pH, and conductivity from the flow-through cell, and for observation of water quality.

13. Measure the discharge rate of the pump with a flow meter or container of known volume and a stopwatch or watch with a second hand. Also, measure the water level and record both flow rate and water level on the groundwater sampling log. Continue purging, and monitor and record the water level and pump rate at selected intervals during purging.

14. Purge a minimum of three well volumes or until the well is dry with the submersible pump and containerize the purge water until it can be discharged to the City of Phoenix sanitary sewer.

15. Take temperature, conductivity, and pH measurements after evacuation of each groundwater monitoring well volume, at a minimum, to determine whether the water chemistry has stabilized. The following values between consecutive readings indicate adequate stability of the water chemistry:
    - Temperature within ±10%
    - pH within ±0.1 pH unit
    - Conductivity within ±10%;
16. If the water quality parameters are not stable, continue purging and measuring temperature, pH, and conductivity after each well volume, until parameters have stabilized.
17. If the groundwater monitoring well goes dry during purging, then samples will be collected as soon as the well has sufficient recovery (80% gauged depth) to permit sample collection or no sooner than 2 hours after purging. Samples will be collected no later than 24 hours after purging is complete.

5.6.3 Groundwater Monitoring Well Sampling

Once the minimum purge volume has been extracted and the groundwater field parameters have stabilized implement the following procedures to collect samples from the monitoring well while it is being purged:

1. Assemble decontaminated sampling equipment.
2. Fill out identification labels for sample bottles for each well.
3. Slow the flow rate from the portable submersible pump to the flow cell until the drawdown in the well stabilizes.
4. Disconnect the discharge tube from the flow cell and position the discharge tube over a container to collect the discharge water.
5. Don the proper personal protective equipment (nitrile gloves, etc.) and begin filling the sample containers.
6. Fill the VOC sample vials completely so the water forms a convex meniscus at the top, then cap so that no air space exists in the vial. Turn the vial over and firmly tap it to check for the presence of bubbles in the vial. If air bubbles are observed in the sample vial, remove lid and add additional water. Replace lid and check for bubbles again. Repeat until no bubbles remain in the sample vial.

7. Record time of sampling.
8. Continue sampling until all sample containers are filled.
9. After sampling is complete, remove the submersible pump and associated sampling equipment from the well.
10. Replace and lock the well cap.
11. Complete field documentation including the chain-of-custody.
12. The disposable sampling equipment that will be subsequently used and discarded (gloves, tubing, etc.) will be packaged and properly disposed. All other equipment will be decontaminated following the procedures outlined in Section 5.11.

If the well pumps dry and therefore cannot be sampled with a submersible pump, bailers will be used to collect the sample by implementing the following procedures:

1. Use only disposable Teflon bailers with a double-check valve and bottom emptying control device for sampling.
2. Attached a new or decontaminated line to the bailer.
3. Lower the bailer slowly and gently into contact with the water in the well.
4. Lower the bailer to the central portion of the wetted screen interval.
5. Retrieve the bailer smoothly, and slowly drain the water into the sample containers through the bailer's bottom discharge control device.
6. Complete steps 11 and 12 described above.

QC samples are collected during groundwater sampling according to Section 5.10 of this FSP and the QAPP. An equipment list for collecting groundwater samples is presented in Appendix C.

5.7 *AQUIFER TESTING*

Aquifers tests will be performed to provide information about the Shallow and Intermediate aquifer zone characteristics. Slug tests will be performed across the OU3 Study Area, in both the Shallow and Intermediate aquifer zones to estimate the horizontal hydraulic conductivity in each aquifer zone. Both the Shallow and Intermediate Zones will undergo constant-rate

discharge tests to allow for the calculation of specific yield, storativity, hydraulic conductivity transmissivity, and other aquifer parameters.

5.7.1 *Slug Test*

The slug test(s) will involve displacing a known volume of water in the groundwater monitoring well instantaneously and recording groundwater level changes as the well recovers to static conditions. This will be achieved by rapidly introducing a "slug" into the well to create an instantaneous rise in the water level, then recording water level decline to static conditions (falling head or slug-in test). The slug will be a solid PVC cylinder approximately 2 to 3 inches in diameter and 8 to 10 feet long attached to a wire line. After the groundwater monitoring well has recovered to static conditions, the slug will be removed from the well to create an instantaneous decline in water level and the water level rise will be recorded (rising head or slug-out test). It should be noted that this test can only be performed when the water level is above the well screen; otherwise the data are not representative.

Falling head and rising head tests will be conducted in each selected well. An electronic pressure transducer/data logger system will be used to record the water level changes. The specifications of the electronic pressure transducer/data logger system will be provided to the technical team an Aquifer Test Technical Memorandum.

The data will be stored in the data logger and subsequently downloaded to a computer. Because the water level recovery rate during a slug test declines at an exponential rate, water level changes will be recorded at logarithmic intervals with more frequent measurements in the initial few minutes and less frequent measurements as time elapses. The following table illustrates a typical water level data collection intervals based on time:

Time (sec)	Number of readings
0-20	Every 0.5 second
20-60	Every 1.0 second
60-240	Every 2.0 seconds
240 to 600	Every 5.0 second
600 to 1200+	Every 10.0 seconds

The slug test will be conducted by implementing the following procedure:

1. The pressure transducer and cable will be decontaminated in accordance with the procedures used for groundwater sampling equipment as described in Section 5.11 for Fluid Level Measurements and Groundwater Sampling.
2. Pertinent information will be recorded into the electronic data logger before beginning the slug test. The type of information may vary depending on the equipment used (the operator's manual will be consulted for the proper data entry sequence to be used).
3. Depth to groundwater will be measured with an electric measuring tape to establish the baseline groundwater level.
4. The pressure transducer and cable will be installed in the well to a depth below where the bottom of the slug will be placed but at a minimum of 2 feet from the bottom of the groundwater monitoring well. The depth of submergence will be checked to ensure that it is within the design pressure range stamped on the transducer.
5. The accuracy of the data logging equipment will be tested by raising and lowering the transducer by a known amount in the well and checking to be sure that the data logger is recording the correct information.
6. The depth to water and depth to pressure transducer will be marked on the rope used to lower and raise the slug. Care will be taken to avoid hitting the transducer with the slug and to permit more instantaneous insertion of the slug into the water. The first mark will indicate where the slug can be lowered to avoid touching the water surface; the second mark will indicate to what point the slug can be lowered during the test to avoid touching the transducer but be fully immersed.
7. The pressure transducer cable will be secured to the vault, such that the transducer is maintained at a constant depth during the test.
8. The pressure transducer cable will be connected to the electronic data logger.
9. A convenient reference point will be entered into the data logger to begin hydraulic head readings. For example, the static water level may be set to a reference of "0" feet or the groundwater elevation relative to feet, mean sea level.
10. The data logger will be set to record the water level data at logarithmic time intervals (e.g., every second for the first 10 seconds, every 10 seconds from 10 to 100 seconds, etc.). The time between

measurements will be selected to adequately define the recovery curve (typically a maximum of 1-minute intervals).

11. The depth to water will be measured and recorded to the nearest 0.01 foot, as will the time, just before each test. The pressure transducer design range will be entered into the data logger according to the manufacturer's instructions. The transducer design range is typically stamped on the side of the transducer.
12. The moment of slug addition and slug removal will be considered as time equals "zero" for the slug-in (falling head) and slug-out (rising head) tests, respectively.
13. For slug-in tests, the slug will be quickly and gently lowered into the water until the top of the slug is below the static water level, which will produce an instantaneous rise in water level.
14. The data logger will be started just before the slug is immersed to ensure that all of the initial response is recorded. Test data will be viewed using a computer during the test to check progress of the test. The test will be terminated when the water level is recovered to within 90 percent of static levels.
15. After the slug-in test has been terminated, the slug-out test will be initiated. The hydraulic head reference point will be reset, if needed. The slug will be removed as quickly and gently as possible while the data logger is restarted. The slug-out test will be terminated when the water level has recovered to within 90 percent of static level.
16. The slug will be retrieved.
17. The recorded data will be saved.
18. The battery will be disconnected at the end of the day's activities.
19. The field data will be reviewed for completeness.
20. Any test will be repeated as needed, based on a review of the field data.

5.7.2 *Constant Discharge Pump Test*

The constant discharge pumping tests will be done by pumping water from one well for a 24-hour period at a constant-rate and measuring the effects of the pumping on the water table in the pumping well and nearby observation well(s). The type of information collected during the test includes flow rate, water level versus time, and distance from the pumping well to the observation wells. The pumping rate used for the

constant discharge pump test will be selected by conducting a step drawdown test of up to three discharge rates to evaluate the performance of the selected well(s). The discharge rate that produces a sustainable draw down that is adequate for the test objectives will be used for the constant discharge pump test.

The water level measurements will be conducted with pressure transducers placed near the bottom of the pumping and observation groundwater monitoring wells, which are connected to a data logger. Barometric loggers will also be used to compensate for any barometric changes during the pump test. Barometric readings will be taken at the same time as the water level readings to allow for corrections to reflect the accurate water level. These transducers and data loggers will be fully maintained and calibrated per the manufacturer's specifications. Manual water level measurements will also be taken during the test at both the pumping and observation wells. The following procedures will be conducted during the constant discharge pump test:

1. Measure the depth to water and the total depth of the groundwater monitoring wells used for the test. The pressure and barometric transducers will be installed at least 1 week before the pump tests on the selected wells in order to allow for background data collection.
2. Mark the transducer cable and the discharge hose/electrical cable of the pump with tape to indicate the pump placement depth. The bottom of the transducer should be placed several inches above the bottom of each groundwater monitoring well. The pump should be placed several inches above the transducer.
3. The barometric logger will be placed in the observation well and set to collect data points at the same time as the rest of the pressure transducers. Secure the data loggers to the well.
4. Place the pump and pressure transducer in the groundwater monitoring well and secure the transducer and pump wires to the well to ensure that they will not slip during the test.
5. Connect the pump to a totalizer then feed the pump discharge hose into the City of Phoenix sanitary sewer or other pre-approved container. Monitor and record the amount of water being discharged on to the aquifer test forms.
6. Attach the transducer to the data logger.
7. Compare and record transducer readings and manual water column measurements.

8. Ensure that the appropriate time intervals for logging water level data are programmed into the data logger. Common time intervals are as follows:

Time (minutes)	Time of Readings
0-10	Every 0.5 minute
10-20	Every 2 minutes
20- 60	Every 5 minutes
60 to 120	Every 10 minutes
120 to 120+	Every 20 minutes

9. The pump should remain submerged throughout the test. Start pumping and gauge and set flow rate. A pump with a variable speed motor or a gate-type valve and flow meter on the discharge hose will be used to adjust and monitor the discharge rate. Turn off the pump.
10. Ensure that the water level is at its original measurement. Note the reading on the data logger that is representative of the original water level.
11. Begin data logger data acquisition, and then immediately start the pump.
12. Monitor the flow rate and water column periodically during the test. If a pump has a variable speed motor, the motor speed may need to be increased as the water level in the pumping well declines to maintain the target discharge rate. If the pump does not have a variable speed motor, the valve on the discharge hose will need to be opened gradually as the water level in the pumping well declines to maintain a constant discharge.
13. Water samples will be collected periodically during the pump test to check for trends in COC concentration during the test. Samples will be taken at the following times:

Time of sample (min)
30 minutes
360 minutes
720 minutes
1440 minutes

14. Stop the discharge test by turning off the pump.

15. Allow the data logger(s) to continue recording and continue to take manual water level readings in both the pumping and observation wells until the well(s) return to static water level. Manual water level measurements will be taken in the same time frame as in Step 8.
16. Download the data to an output file into AQTESOLV program (version 4.5) to analyze the data.

5.7.3 *Aquifer Test Data Analysis*

Aquifer test data will be downloaded from the data loggers on to a laptop or other portable device for compilation and analysis. The data will be corrected for barometric pressure changes using software provided by the data logger manufacturer. The corrected data will then be analyzed, based on aquifer conditions, using appropriate analytical methods such as Bouwer and Rice; Hvorslev; Cooper, Bredehoeft, and Papadopoulos (1967) for the proposed slug tests, the Theis and Cooper-Jacob methods for the constant-rate discharge tests of an unconfined aquifer, and Hantush for constant-rate discharge tests of a leaky aquifer. An Aquifer Test Technical Memorandum will be submitted to the technical team with further detail on specific methods for data analysis.

5.8 *DISPOSAL OF INVESTIGATION-DERIVED WASTE*

To characterize IDW for transportation, disposal, or recycling, representative samples will be collected.

The drill cuttings produced during the drilling activities will be collected using a tilt hopper and temporarily stored in roll-offs. The roll-offs will be lined with plastic tarps and drill cuttings will be covered at all times unless access is necessary to add or sample material. A composite soil sample will be collected from the drill cuttings and submitted to the laboratory to provide representative sampling results for the waste stream. The drill cuttings will be analyzed for the following: VOCs using USEPA Test Method 8260B, polynuclear aromatic hydrocarbons (PAHs) using USEPA Test Method 8310, Resource Conservation and Recovery Act (RCRA) 8 Metals, boron, copper, manganese, and zinc using USEPA Test Method 6010B/7471A, polychlorinated biphenyls (PCBs) using USEPA Test Method 8082, pesticides using USEPA Test Method 8081A, chromium VI using USEPA Test Method 7196, and cyanide using USEPA Test Method 9010B. The analytical results will be used to characterize the waste and to establish a disposal profile at a USEPA-approved disposal or recycling facility.

Groundwater monitoring well development water, purge water, and decontamination fluids will be contained and stored in 55-gallon drums or another approved storage vessels prior to disposal. Composite sample(s) will be collected from the vessel using disposable bailers to ensure collection of representative samples. The samples will be analyzed for the following: VOCs using USEPA Test Method 8260B, PAHs using USEPA Test Method 8310, PCBs using USEPA Test Method 8082, and pesticides using USEPA Test Method 8081A. The analytical data will be used to characterize the waste and to apply for a City of Phoenix Sanitary Sewer Discharge Permit for IDW water disposal in the City of Phoenix sanitary sewer system pursuant to Phoenix City Code Section 28-8, or to meet other USEPA-approved disposal or recycling facility requirements. An alternative USEPA-approved disposal or recycling facility may also be used to properly transport and dispose of IDW water.

Groundwater extracted during the proposed aquifer testing will be discharged into the City of Phoenix sanitary sewer or containerized until disposal is arranged. The previous groundwater sampling round's analytical data will be used to characterize the waste and to apply for a City of Phoenix Sanitary Sewer Discharge Permit for IDW water disposal in the City of Phoenix sanitary sewer system pursuant to Phoenix City Code Section 28-8. If needed, groundwater analytical data collected during the aquifer test may be used to characterize the water for an alternative appropriate disposal.

5.9 FIELD EQUIPMENT CALIBRATION

Field equipment will be calibrated prior to each sampling event according to manufacturer's recommendations using manufacturer's standards. The equipment, calibration, and maintenance information will be documented in the instrument calibration log (Appendix A). The frequency of calibration is dependent on the type and stability of the equipment, the methods used, the intended use of the equipment, and the recommendations of the manufacturer. Detailed information regarding the calibration and frequency of equipment calibration is provided in specific manufacturer's instruction manuals. Field equipment requiring repair, replacement, or recalibration will be removed from service if the condition cannot be repaired following the manufacturer's procedures that will be provided at the site.

5.10 QUALITY CONTROL SAMPLING

QC procedures will be implemented using methods that will ensure the project's data needs for completeness, comparability, representativeness, accuracy, and precision are achieved. As such, the soil, groundwater, soil vapor, and IDW sample analyses will be completed in accordance with the USEPA methodologies. Field sampling precision and data quality will be evaluated through the use of field blanks, trip blanks, equipment rinsate blanks, blind duplicates, and MS/MSDs. Sample integrity during shipment is monitored with temperature blanks. A summary of QA/QC samples and frequency is listed in Table 5-3.

5.10.1 Duplicate Samples

Duplicate samples are collected to monitor the precision of the field sampling and analytical process, as well as to provide information regarding the homogeneity of the sample matrix. One duplicate sample will be collected for every 20 groundwater and 10 soil vapor samples.

Soil vapor duplicate samples will be collected during the soil vapor monitoring wells sampling event. One soil vapor sample duplicate will be collected for approximately every 10 samples during the sampling of the soil vapor monitoring wells, or one per day. Duplicate samples will be collected by the following procedures:

1. Collected in separate sample containers, at the same location and depth; and
2. Collected immediately after the original sample.

All soil vapor duplicate samples will be collected by using the same procedures described in Sections 5.4.3 and 5.4.5.

Groundwater duplicate samples will be collected during each round of sampling of the groundwater monitoring program. The duplicate samples will be collected for every 20 groundwater samples. Duplicate samples will be collected in separate sample containers.

Groundwater will be analyzed for VOCs by USEPA Test Method 8260B and for semivolatile organic compounds by USEPA Test Method 8270; therefore, three 40-milliliter vials and two 1-liter amber bottles are required for each sample. When retrieving a groundwater sample and a sample duplicate, six 40-milliliter vials and four 1-liter amber bottles will

be filled. Vials labeled for the primary sample will be used to collect the first, third, and fifth vials collected; vials labeled for the field duplicate will be the second, fourth, and sixth vials collected. The bottles labeled for the primary sample will be the first and third bottles collected; bottles labeled for the field duplicate are the second and fourth bottles collected.

5.10.2 *Split Samples*

In addition to soil vapor duplicate samples, the USEPA or ADEQ may request that a single split sample be collected during each soil vapor monitoring event. Split samples will be collected from selected soil vapor monitoring well locations in conjunction with the soil vapor sampling by the procedures described in Section 5.4.5. All split samples will be collected in 1-liter Summa canisters and submitted to a fixed-based laboratory for USEPA Test Method TO-15 analysis.

5.10.3 *Field Blanks*

Field blanks are samples containing an assumed, analyte-free matrix, and are collected and processed in exactly the same manner as equivalent environmental samples (e.g., for groundwater, clean water is poured into a sample container in the same physical location where the environmental sample is collected and is subsequently handled, processed and analyzed exactly as an equivalent environmental sample). The field blank is used to identify contamination resulting from field sample collection techniques. The source of the water used for field and equipment blanks will be identified in the field sampling logs or field notes. Field blanks will be designated as described in Section 4.1.4.

Field blanks for the soil vapor sampling will be prepared by pulling ultra-pure air through a length of tubing into a sampling container. The tubing shall be a clean section of the same tubing as used for sample extraction.

5.10.4 *Equipment Rinsate Blanks*

The equipment rinsate blank is a sample of reagent grade, analyte free, water poured into, over, or pumped through the sampling device, collected in a sample container, and transported to the laboratory for analysis in the same manner as environmental samples. These blanks are used to assess the effectiveness of equipment decontamination procedures. Equipment rinsate blanks are prepared in accordance with ASTM D 5088-90 (Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites) protocol and are used to monitor the

effectiveness of the decontamination process. One equipment rinsate blank sample per type of sampling equipment utilized will be collected per each day of the sampling event. The equipment rinsate blank will be analyzed by the same methods as the environmental samples collected at the sampling location. Equipment blanks will be designated as described in Section 4.1.4.

All soil vapor sampling equipment is either disposable or dedicated; therefore, the collection of equipment blanks is not necessary.

5.10.5 *Trip Blanks*

The trip blank for water and soil samples consists of a sample vial filled in the laboratory with reagent-grade, analyte-free water, transported to the sampling site, handled like an environmental sample, and returned to the laboratory for analysis. The trip blank is used to detect any cross contamination during the shipment, handling, and storage of environmental samples. A trip blank will be shipped in every cooler containing environmental samples collected for VOC analysis.

Per the requirements of the ASGI, whenever soil vapor samples are shipped off site for analysis, a minimum of one trip blank per day will be collected and analyzed for the target compounds. Trip blanks, consisting of laboratory grade, ultra-pure air, will be prepared by the laboratory to evaluate if shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected soil vapor samples. Trip blanks will be designated as described in Section 4.1.4.

5.10.6 *Matrix Spike and Matrix Spike Duplicate Samples*

MS/MSD samples are collected to measure the precision and accuracy of both the field sampling and laboratory analysis, as well to serve as an indicator for the presence or absence of matrix effects. This measure is required for soils and waters, but is not applicable to soil vapors. Extra volume (typically two extra containers) for one sample will be collected for every 20 environmental samples for soils and waters. The extra volume is submitted to the laboratory for MS/MSD analysis. MS/MSD samples will be analyzed by the same methods as the environmental samples and are discussed further in Section 3.5.2 of the QAPP under "Laboratory Quality Control Requirements." MS/MSD samples will be designated as described in Section 4.1.4.

5.10.7 *Performance Evaluation Samples*

Performance evaluation (PE) samples for water will be included as a program QA measure. One PE sample will be collected per groundwater sampling event. This sample will be obtained from a commercial vendor and will contain certified concentrations of the target compounds which are anticipated to be identified at the site. The PE sample will be submitted to the laboratory double-blind; the sample will be introduced into the sampling stream in the field and will be analyzed by the laboratory without the laboratory's knowledge of its significance. Vendor-supplied control limits will be used to evaluate the results of the PE sample analysis with respect to proper identification of the spiked compounds and the acceptability of the resulting quantification. Any necessary corrective action will be based upon the severity of the deficiency in the identification and quantification of the spiked target compounds. Corrective action may include up to rejection of the data for that compound or class of compounds. PE samples will be designated as described in Section 4.1.4.

5.10.8 *Temperature Blank*

The temperature blank is a blank water sample provided by the laboratory. The temperature blank is used to verify the temperature of the sample set submitted to the laboratory. At the time of sample receipt, the laboratory measures the temperature of the water blank as a measure of the sample preservation conditions. If the temperature falls outside the required range of 4 degrees Celsius (°C) ± 2°C, preservation has not been within method requirements and data may need to be qualified during validation. One temperature blank will be placed in each sample cooler to be submitted to the laboratory.

The following table lists the applicable QC samples that will be utilized during the investigation activities.

Table 5-3 Quality Control Sampling Program

Quality Control Sampling Program		
	Water	**Soil Vapor**
Number of Environmental Samples	8 – quarterly for new wells for One year 42 – semi-annually	75 – includes purge test
QA/QC Measure		
Duplicate	1 every 20 samples	1 per every 10 samples collected, minimum of 1 per day
Split	upon request	upon request
Field Blank	1 per event or change in source water	1 per 10 samples, minimum of 1 per day
Equipment Rinsate Blank	1 per type of sampling equipment per day	NA
Trip Blank	1 per cooler	1 per cooler
MS/MSD	1 every 20 samples	NA
Performance Evaluation	1 per every groundwater sampling event	NA
Temperature Blank	1 per cooler	NA

5.11 DECONTAMINATION

To avoid cross contamination between sampling intervals and locations, decontamination of equipment and non-disposable sampling devices will be conducted. Disposable equipment intended for one-time use will not be decontaminated, but will be packaged for appropriate disposal after use. Decontamination will occur prior to and after each piece of equipment is used. All sampling devices and drilling equipment used will be decontaminated following the procedures described in the following sections.

During the investigation process, certain heavy equipment could be used for drilling, surface coring, etc. This equipment will be dry-decontaminated, consisting of brushing all loose dirt and debris from the vehicle. In the event that soils are wet and cannot be thoroughly and easily removed, an equipment decontamination area will be set up, and the equipment will undergo a wet decontamination process. Soil or other debris that is removed during the decontamination process will be collected on plastic sheeting and transferred to the appropriate solid waste storage area and container (drums or roll-off) for characterization and disposal.

5.11.1 Soil Vapor

The sampling of the soil vapor monitoring wells will utilize dedicated or disposable equipment; therefore, decontamination will not be required. Summa canisters will be cleaned and certified by the laboratory between uses by three evacuation/pressurization cycles as detailed in USEPA Test Method TO-15. One canister from each cleaning batch will be filled with ultra-pure air and analyzed to verify the effectiveness of the decontamination process by the fixed-based laboratory.

5.11.2 Soil Boring and Soil Sampling

Drilling equipment including casing, drill bits, drill rods, and drill pipe will be decontaminated using a hot water pressure washer prior to moving to each new drilling location. Pressure washing will be conducted in a designated area, which will be lined with plastic sheeting. Decontamination fluids will be collected in the liner and transferred to the appropriate solid waste storage area and vessel for characterization and disposal.

Other soil sample equipment, including split-spoon samplers, slide-bar samplers, brass sleeves, hand-augers, hand trowels, and any other equipment used to collect soil samples, will be decontaminated using a 3-bucket wash and rinse methodology by the following procedures:

1. Spray, rinse, wash, and scrub equipment using a solution of Alconox® (or equivalent) and potable water contained in one 5-gallon bucket;
2. Rinse with potable water in one 5-gallon bucket;
3. Rinse with distilled water contained in one 5-gallon bucket; and
4. Air-dry the equipment.

5.11.3 Groundwater Monitoring Program

If non-dedicated groundwater water sampling equipment is required for groundwater sampling then the equipment will be decontaminated according to the following procedures:

1. The exterior of the pump or other non-dedicated equipment will be placed on a piece of Visqueen film and then washed with a power washer.
2. The exterior of the pump will be washed with Alconox. Any piping or tubing used, such as a reel pump, will have Alconox sprayed on both the exterior and interior of the piping/tubing.
3. The Alconox-covered equipment will be washed by the power washer. All piping for the non-dedicated pump will be washed both inside and out. Dedicated tubing will be washed by circulating water though the tubing, via the discharge manifold, so that the Alconox flows through the tubing and out of the pump.
4. The pump will then be placed in a container containing distilled water only and rinsed. The pump will be allowed to run until approximately 5 gallons have been pumped. Any pumps not on dedicated tubing will have distilled water poured over them.
5. The electronic water level probe used for collecting water levels will be sprayed with a mixture of potable water and Alconox. The probe will be given a clean rinse using distilled water and allowed to air dry.

Decontamination fluids will be transferred to approved waste storage containers for temporary storage before discharge into the City of Phoenix sanitary sewer or transport to a USEPA-approved waste disposal facility, pending waste characterization and disposal. Residual sediments will be placed in roll-offs located in the designated area for characterization and disposal.

The electronic water level or interface probe used for collecting water levels will be sprayed with a mixture of potable water and Alconox. The probe will be given a clean rinse using distilled water and allowed to air dry.

6.0 SAMPLE HANDLING AND ANALYSIS

Analytical methods for soil vapor, soil, and groundwater samples, collected within each location at the site, are referenced in the QAPP. The QAPP will detail the analytical requirements for each area based upon the historical investigations at the site and the media being sampled. This section of the FSP describes the sample handling and analysis at the site during the investigation activities.

6.1 Soil Vapor Samples

Soil vapor samples collected during investigation activities will be submitted to a fixed-based laboratory. Sample containers will be in the possession of the responsible field representative at all times. Duplicate samples will be handled with the same procedures. The samples will be either hand-delivered to the laboratory by the responsible field representative or picked up by the fixed-based laboratory's courier service. The samples will be submitted with a completed chain-of-custody form per the procedures outlined in Section 4.3 of this FSP.

Table 6-1 identifies analytical method, sampling containers, sample preservation, and holding requirements for soil vapor samples collected during the Phase III RI.

6.2 Groundwater Samples

Groundwater samples collected during investigation activities for the purpose of data collection and IDW disposal will be submitted to a fixed-based laboratory. Sample containers will be in the possession of the responsible field representative at all times. Duplicate samples will be handled with the same procedures. Samples will be either hand-delivered to the laboratory by the responsible field representative or picked up by the fixed-based laboratory's courier service. The samples will be submitted with a completed chain-of-custody form per the procedures outlined in Section 4.3 of this FSP.

Table 6-1 identifies analytical method, sampling containers, sample preservation, and holding requirements for all groundwater analysis conducted during the Phase III RI.

6.3 Soil Samples

Soil samples collected during the investigation for the purpose of IDW disposal and geotechnical analysis will be submitted to fixed-based laboratory during the investigation activities. Sample containers will be in the possession of the responsible field representative at all times. Duplicate samples will be handled with the same procedures. The laboratory duplicate samples will be either hand-delivered to the laboratory by the responsible field representative or picked up by the fixed-based laboratory's courier service. The samples will be submitted with a completed chain-of-custody form per the procedures outlined in Section 4.3 of this FSP.

Table 6-1 identifies analytical method, sampling containers, sample preservation, and holding requirements for soil samples collected during the Phase III RI.

Table 6-1 Analytical Methods and Procedures and IDW Characterization Analyses

Analytical Methods and Procedures				
Media	**USEPA Test Method**	**Volume and Container Type**	**Preservation**	**Holding Time**
Soil Vapor	TO-15	1L, Summa Canister	None	30 days
Groundwater	VOCs 8260B	3 - 40mL, VOA	Hydrochloric Acid, Stored at 4°C ±2°C	14 days
	[1]SVOCs 8270C	1L, amber glass	Stored at 4°C ±2°C	7 days
Soil (Geotechnical)	Total Organic Carbon	6″ Stainless Steel Soil Sample liner	Chill to 4°C	28 days
	Effective Porosity	6″ Stainless Steel Soil Sample liner	None	28 days
	Dry and Bulk Density	6″ Stainless Steel Soil Sample liner	None	28 days
	Moisture Content	6″ Stainless Steel Soil Sample liner	None	28 days
IDW Characterization Analyses				
Media	**EPA Test Method**	**Volume and Container Type**	**Preservation**	**Holding Time**
Soil	VOCs 8260B	[2]En Core® device	[2]En Core®, frozen	7days, 14 days to analyze extract

Analytical Methods and Procedures				
Media	**USEPA Test Method**	**Volume and Container Type**	**Preservation**	**Holding Time**
			If not frozen	48 hours, 14 days to analyze extract
	TPH 8015AZ R.1	6″ Stainless Steel Soil Sample liner	Stored at 4°C ±2°C	14 days
Groundwater	VOCs 8260B	3 - 40ml, VOA	Hydrochloric Acid, Stored at 4°C ±2°C	14 days
	TPH 8015 GRO	3 – 40mL, VOA	Stored at 4°C±2°C	14 days
	TPH 8015 DRO-ORO	1L, amber glass	Stored at 4°C ±2°C	7 days
	PAHs 8310	1L, amber glass	Stored at 4°C ±2°C	7 days
	[3]Metals 6010B/7470	1L, HDPE	HNO3, Stored at 4°C ±2°C	28 days
	Chromium VI 3500	500mL, HDPE	Stored at 4°C ±2°C	24 hours
	Cyanide 9010B	500mL, HDPE	Stored at 4°C ±2°C	14 days
	PCBs 8082	1L, amber glass	Stored at 4°C±2°C	7 days to extract, 40 days to analyze extract
	Pesticides 8081A	1L, amber glass	Stored at 4°C±2°C	7 days to extract, 40 days to analyze extract

[1]Only 1,4-Dioxane will be analyzed using Method 8270C.
[2] En Core® = Trade name of En Novative Technologies, Inc. see Section 5.4.2 for soil sample collection procedures
[3]Metals = RCRA 8 (As, Ba, Cd, Cr, Pb, Hg, Se, Ag)

VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds
TPH = Total Petroleum Hydrocarbons
PAHs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
HDPE = High Density Polyethylene Bottle
HNO_3= Nitric Acid
GRO = Gasoline Range Organics
DRO = Diesel Range Organics
ORO = Oil Range Organics

The required detection limits for USEPA Test Methods TO-15, and soil and groundwater by USEPA Test Method 8260B are listed in the QAPP. The IDW characterization analysis for soil and groundwater reporting limits are presented in Appendix B of the QAPP. Soil vapor, soil, and

groundwater samples will be compared to the regulatory standards presented in Table 4 of the QAPP. The laboratory will be required to report the lowest quantifiable detection even if this is below the method reporting limit. However, in some cases method detection limits may exceed regulatory standards.

7.0 REFERENCES

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USEPA. 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Groundwater Issue Forum Paper, EPA 542-S-02-001. Office of Solid Waste and Emergency Response. May.

USEPA. 2009. *Administrative Settlement Agreement and Order on Consent for Remedial Investigation and Feasibility Study*. Region IX. Docket No. 2008-17. 23 September.

Figures

Project No. 0096498.01
Date: 05/19/09
Drawn By: R. Olson
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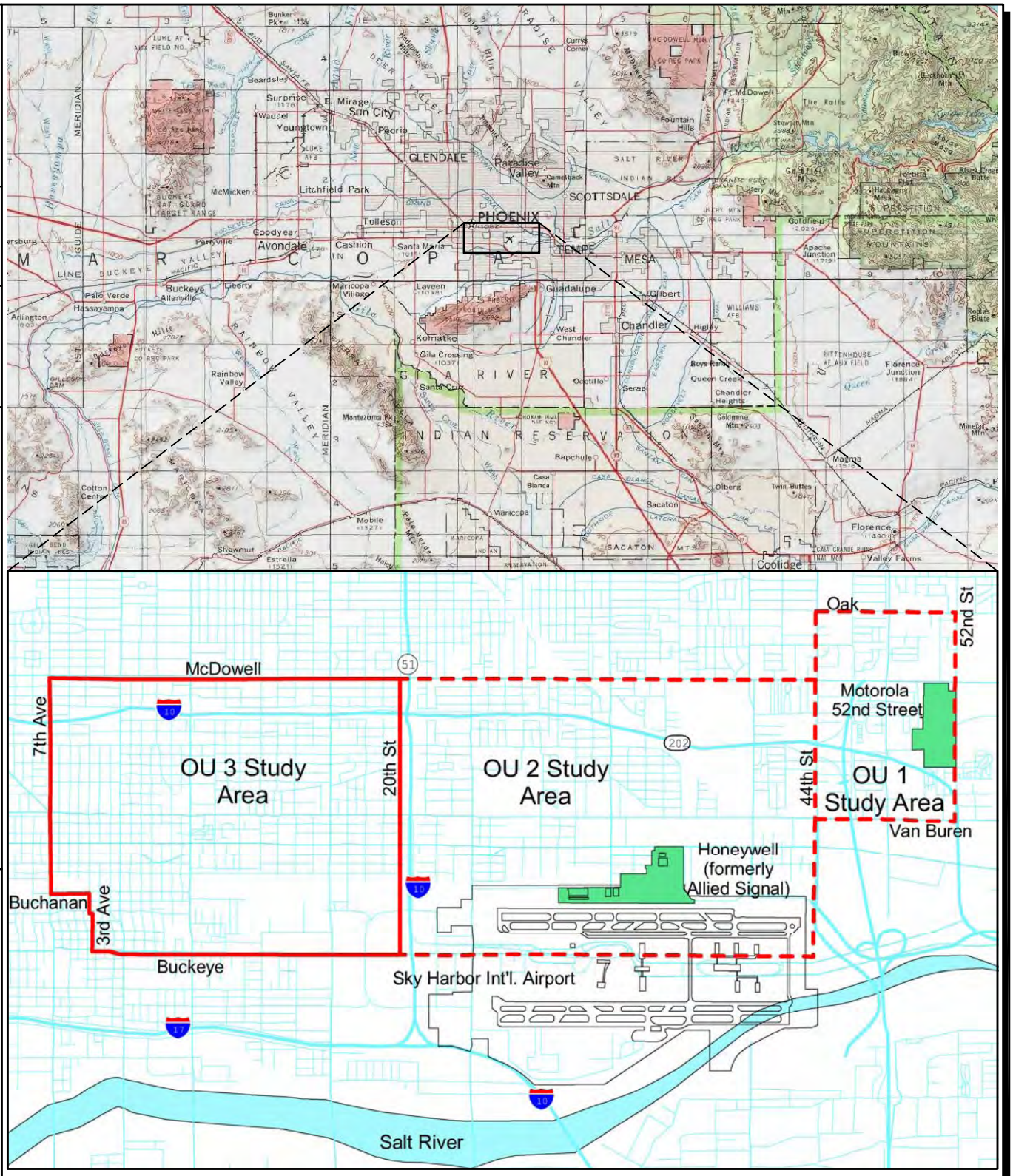


LEGEND

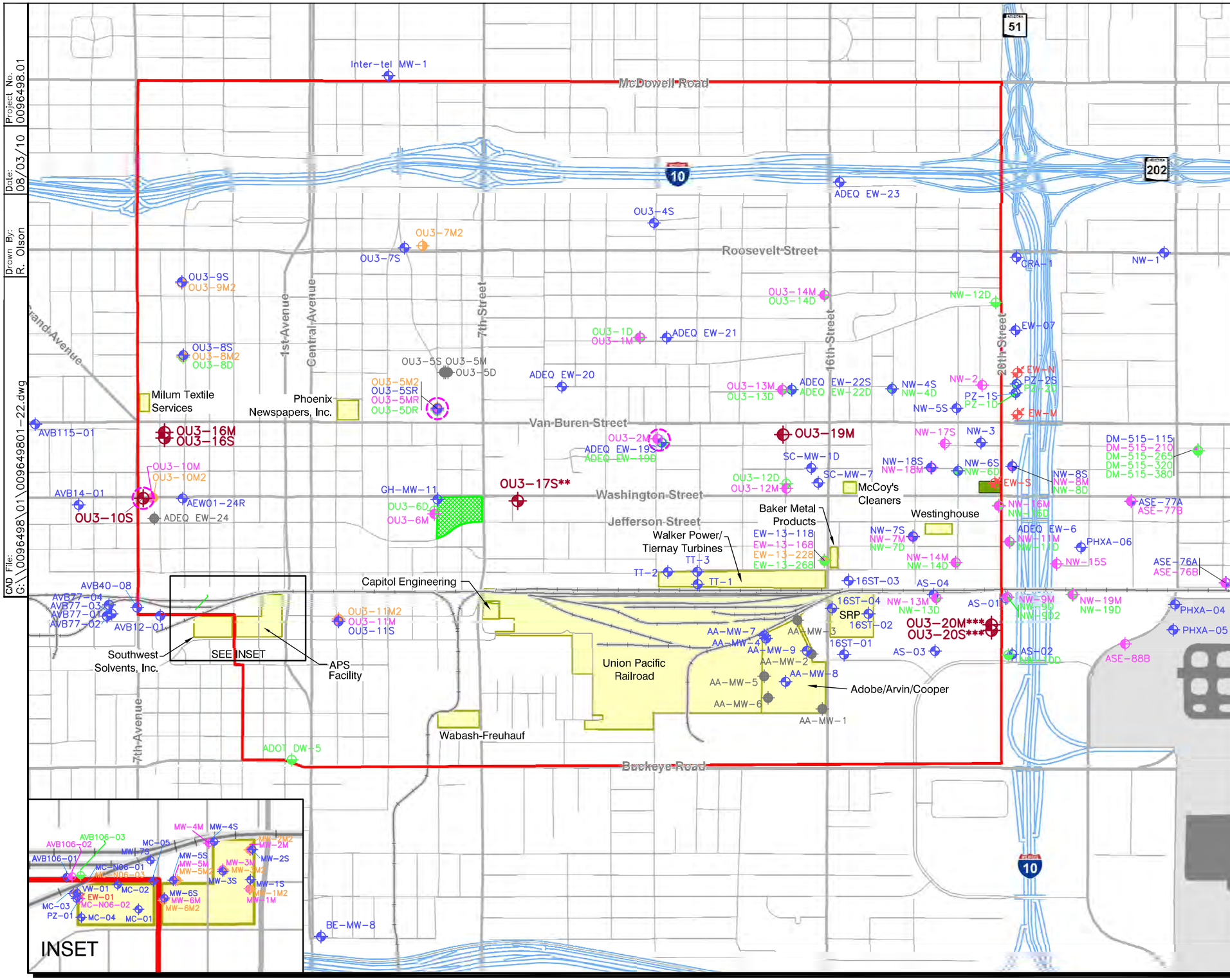
OU3 Study Area Boundary

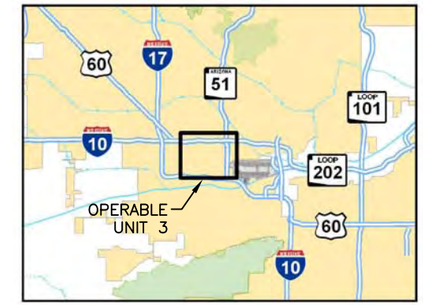
OU1 and OU2 Study Area Boundary

References:
TOPO!® Software
U.S.G.S. 500k Map Series; Phoenix, Arizona
Shaw Environmental, 04/19/04.

Figure 1
Site Location Map
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

ERM 05/09





LEGEND

- Potential Soil Vapor Well Location

Phase III Groundwater Well Locations*:

- Shallow
- Intermediate
- Deep

Existing Monitoring Wells:

- Shallow
- Intermediate
- 2nd Intermediate
- Deep
- Shallow Piezometer
- Deep Piezometer
- Extraction
- Abandoned

- OU-3 Boundary
- OU-2 Remediation Facility
- PRP Location
- COP Wells Area, to be evaluated for use in OU3 and part of a forthcoming Technical Memo

*Assuming all new locations pass utility clearance.
**Well being evaluated in forthcoming Technical Memo.
***Well requires access agreement.

0 1500
Approx. Scale (feet)

Figure 2
Phase III Groundwater Investigation
Proposed Well Locations
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

ERM 08/10

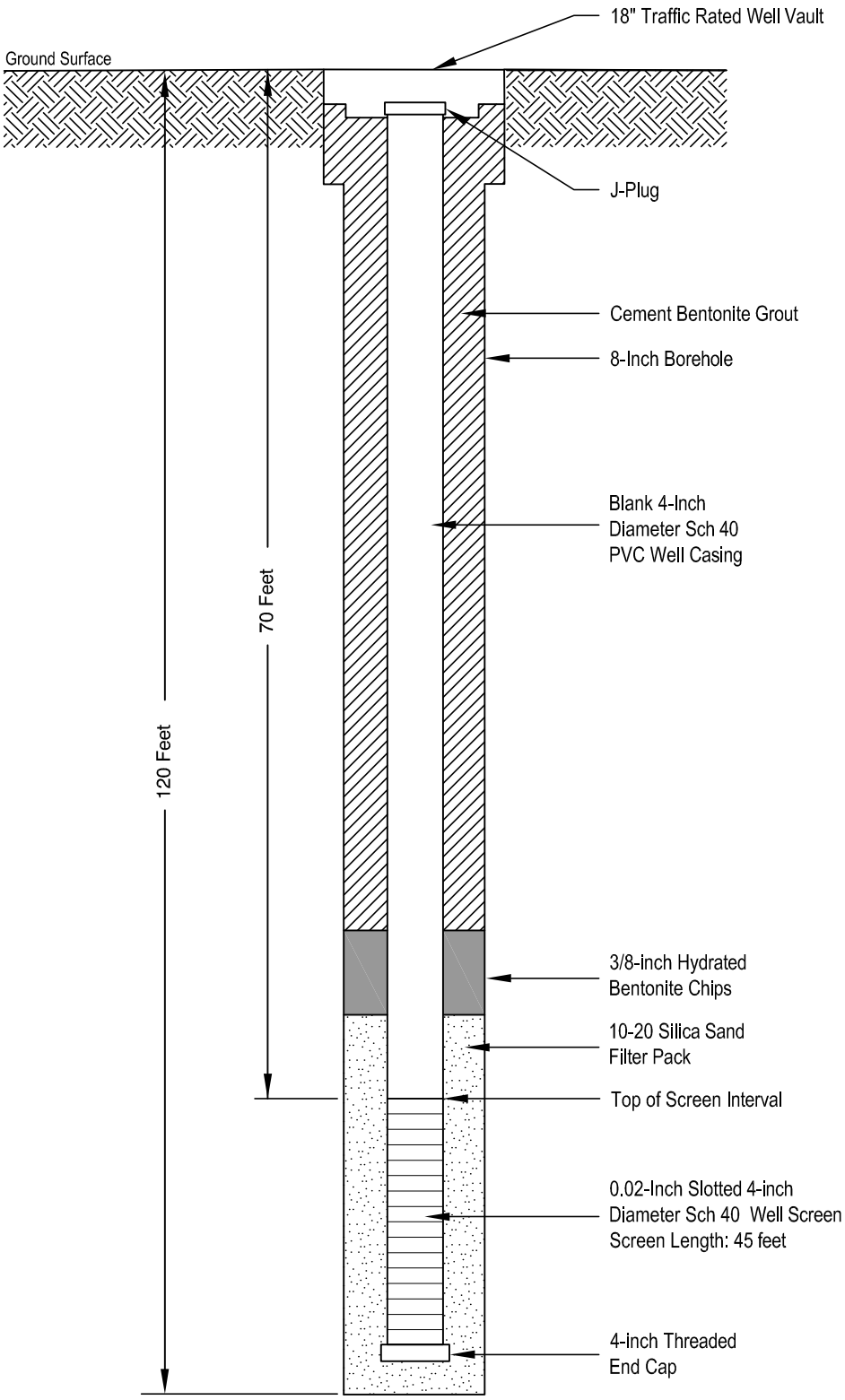


Figure 3

Proposed Shallow Zone Monitoring Well
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

NOT TO SCALE

ERM 03/10

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Drawn By: R. Olson
Date: 03/09/10
Project No. 0096498.001

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Project No. 0096498.001

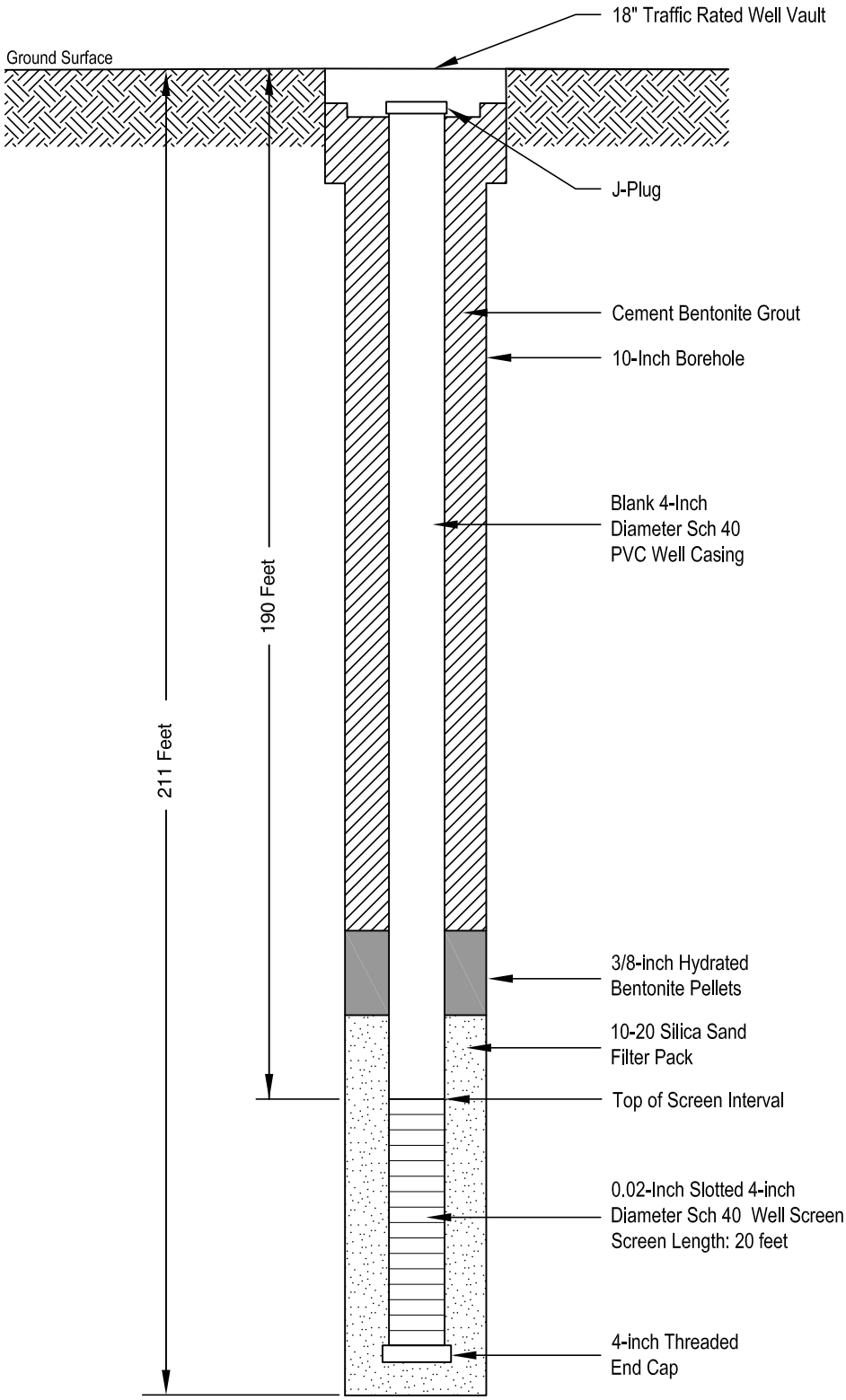

Figure 4

Proposed Intermediate Zone Monitoring Well
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

NOT TO SCALE

ERM *10/09*

Project No. 0096498.001
Date: 08/02/10
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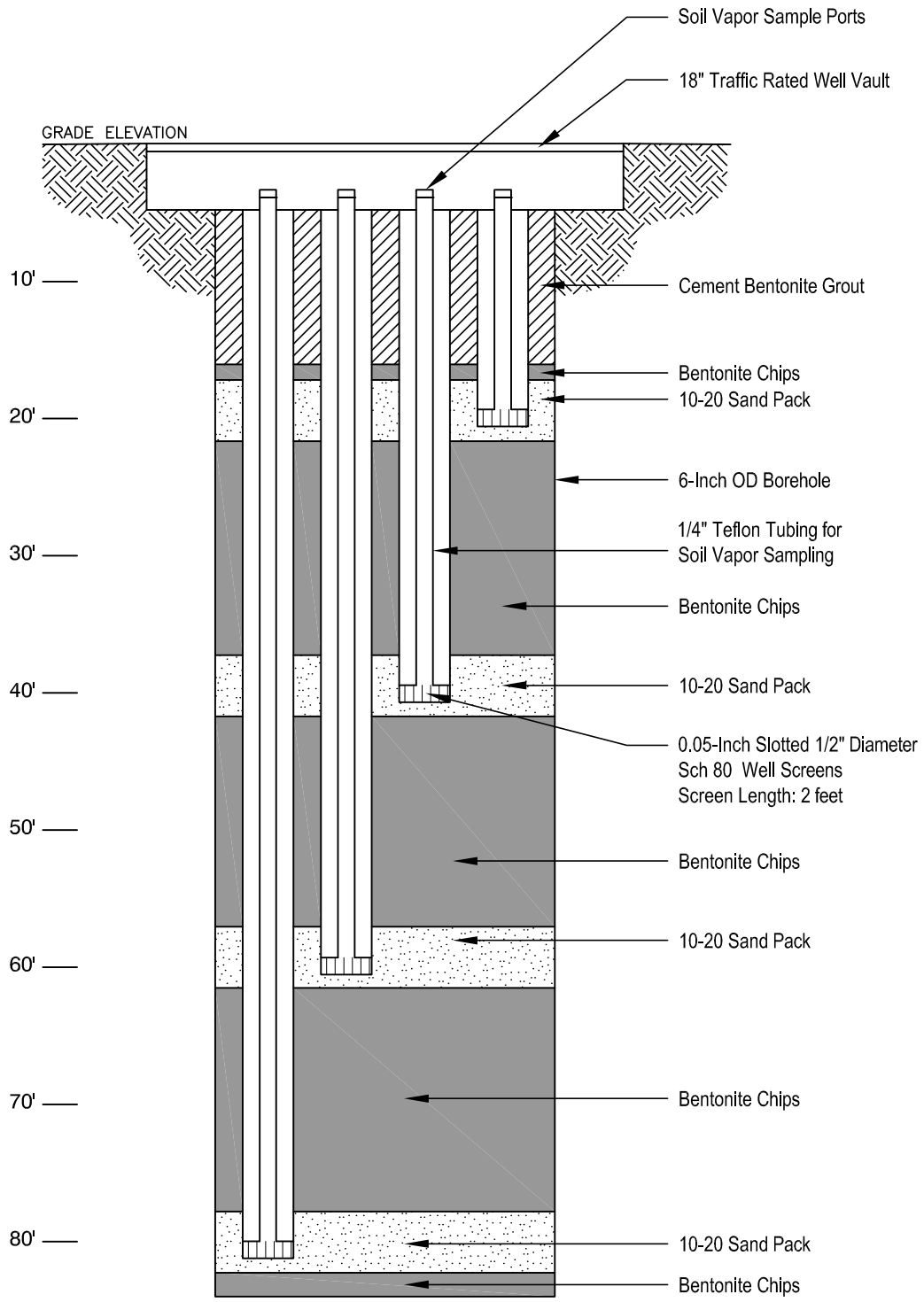

Figure 5
Proposed Soil Vapor Monitoring Well
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

NOT TO SCALE

ERM *08/10*

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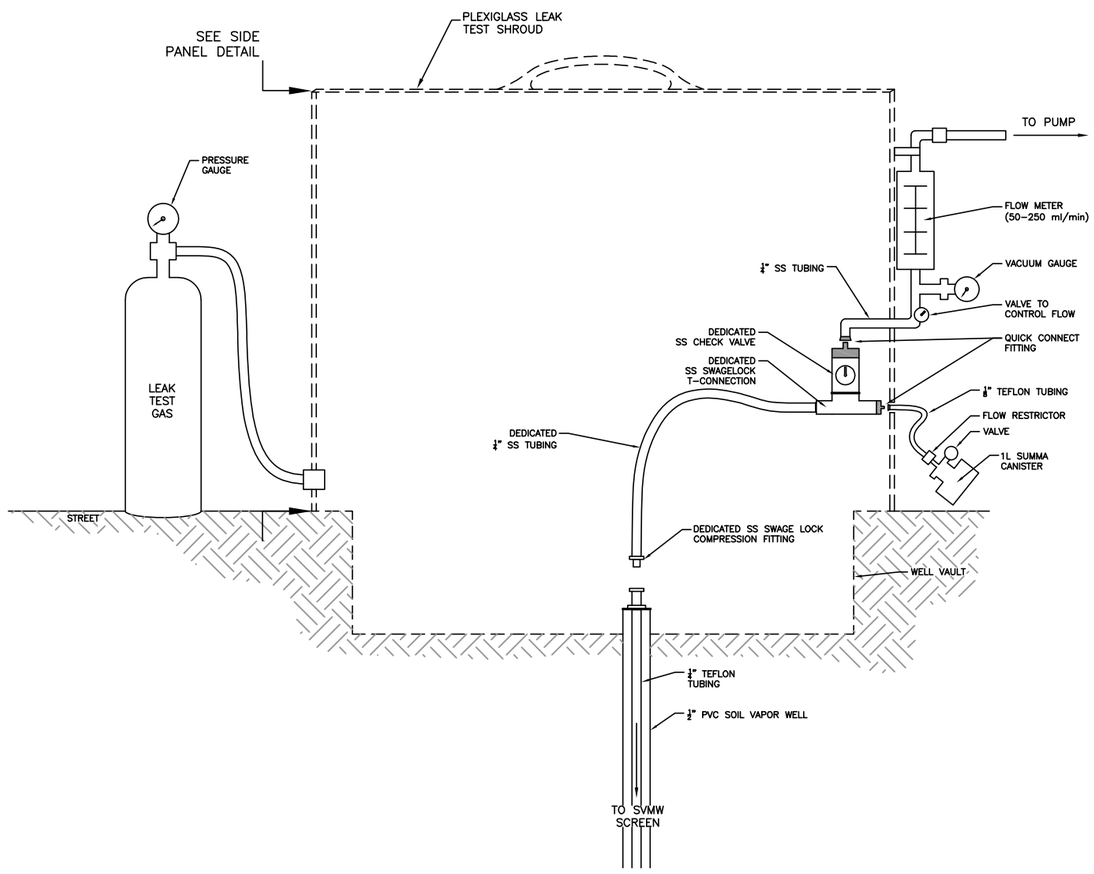
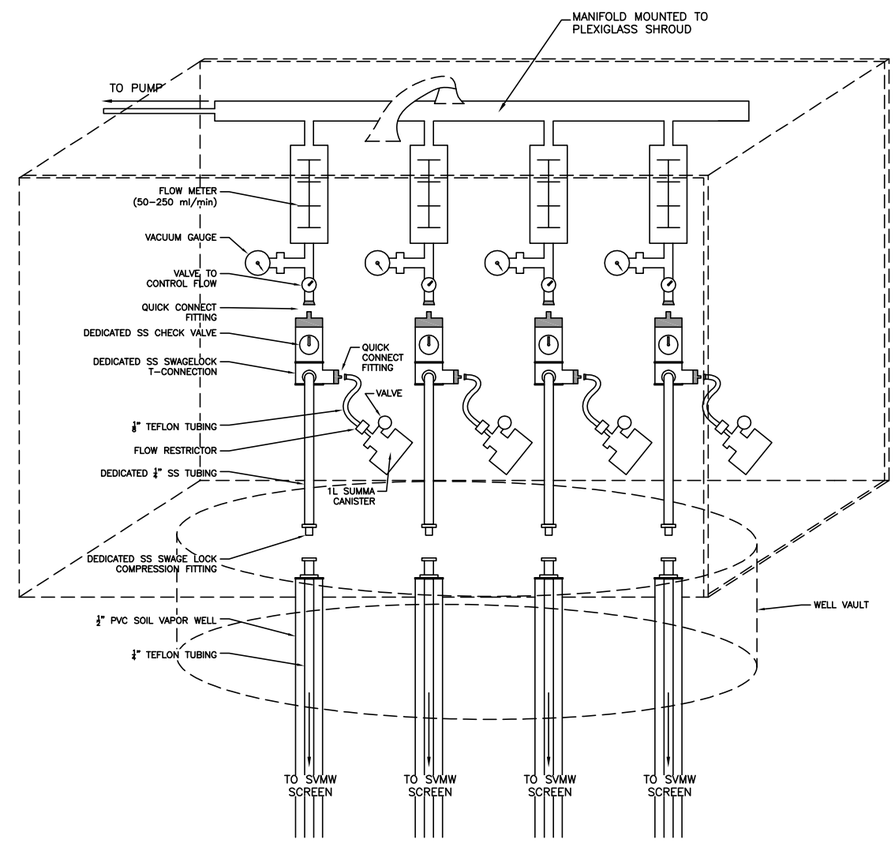


SIDE PANEL DETAIL



NOT TO SCALE

Figure 6
Soil Vapor Well Sampling Manifold
Operable Unit 3 Study Area
Motorola 52nd Street Superfund
Phoenix, Arizona

ERM *08/10*

Appendix A
Field Forms

ENVIRONMENTAL RESOURCES MANAGEMENT
WELL COMPLETION FORM FOR SINGLE WELLS

PROJECT AND PERSONNEL

PROJECT NAME:

PROJECT NUMBER:

CLIENT:

PROJECT MANAGER:

WELL LOGGED BY:

WELL INFORMATION

WELL NUMBER:

WELL LOCATION:

WELL PERMIT NO.:

PERMIT ISSUING AGENCY:

INSTALLATION DATE:

TOTAL DEPTH OF WELL:

WELL TYPE (check all that apply):

___ Soil Vapor Extraction ___ GW Extraction/Injection

___ Air Sparge ___ Groundwater Monitoring

___ Vapor Monitoring

DRILLING INFORMATION

DRILLING METHOD:

AUGER OR DRILL CASING SIZE:

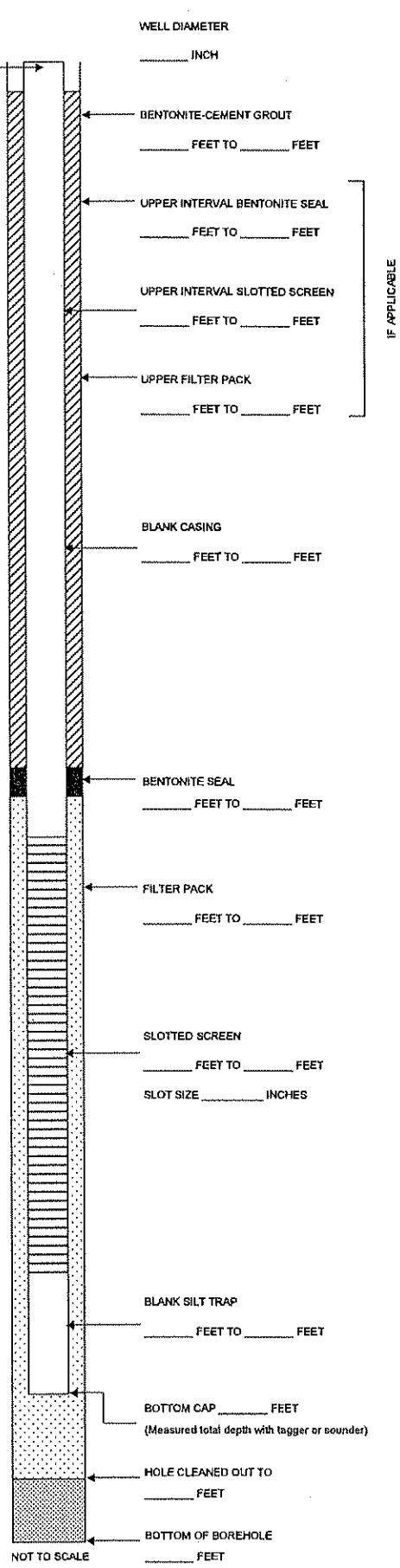
HOLE DIAMETER:

METHOD OF AUGER DECONTAMINATION:

FILTER PACK SURGING/DEVELOPMENT TIME PRIOR TO SETTING BENTONITE SEAL: minutes feet settlement

MATERIALS USED

	Unit (e.g. 50-lb bag)	Estimated No. of Units to be Used	No. of Units Used	Type (e.g. 8-12 size silica sand, Schedule 40 PVC)	Method of Placement (Check One)
FILTER PACK(S)					
Filter Pack (LOWER)					Poured / Tremied
Filter Pack (UPPER)					Poured / Tremied
BENTONITE SEAL(S)					
Chips					Poured / Tremied
Pellets					Poured / Tremied
Powder/Water Mix (Slurry) (Saturated Intervals Only)					Poured / Tremied
GROUT	Gallons				Poured / Tremied
Cement	94-Lb Bags				
Bentonite Powder	50-Lb Bags				
WELL CASING(S)					
Blank Casing	Feet				
Screen	Feet				



For volume estimates:

12-inch-diameter Borehole:	0.785 ft^3/ft
9-inch-diameter Borehole:	0.442 ft^3/ft
6.065-inch ID/6.625-inch OD Schedule 40 PVC Well Casing:	0.239 ft^3/ft
5.047-inch ID/5.563-inch OD Schedule 40 PVC Well Casing:	0.169 ft^3/ft
4.026-inch ID/4.500-inch OD Schedule 40 PVC Well Casing:	0.110 ft^3/ft
2.067-inch ID/2.375-inch OD Schedule 40 PVC Well Casing:	0.031 ft^3/ft
1.049-inch ID/1.315-inch OD Schedule 40 PVC Well Casing:	0.009 ft^3/ft
Filter Pack Sand/Gravel:	0.4-0.5 ft^3/50-lb sack (0.5 ft^3 is commonly assumed)
Grout:	0.1337 ft^3/gallon

BOREHOLE LOG

ERM

Sketch Map of Borehole Location

BOREHOLE NO:
TOTAL DEPTH:
TOP ELEVATION:
WELL ID:

PROJECT NAME:	DRILLING CO.:	WATER LEVEL:
PROJECT NUMBER:	DRILLER:	FREE PRODUCT LEVEL:
SITE LOCATION:	RIG TYPE:	CASING DIA.:
LOGGED BY:	DRILLING METHOD:	SCREEN SLOTTED SIZE:
DATE DRILLED:	HAMMER WT./DROP:	ADWR WELL NO.:
EASTING:	NORTHING:	PAGE OF

DEPTH	TIME	SAMPLE ID	RECOVERY %	BLOW COUNT	FID/PID	USCS	LITHOLOGIC DESCRIPTION

DEPTH	TIME	SAMPLE ID	RECOVERY %	BLOW COUNT	FID/PID	USCS	LITHOLOGIC DESCRIPTION

OU3
Motorla 52nd St Superfund Site
Aquifer Testing - Constant Discharge Test
Field Notes / ERM

Date:
Set up time:
Weather:
Field Staff:

WELL #

Location: OU3 - Superfund Site

Construction:

Construction Depth (feet):
Screened Interval (feet):
Pump Intake Depth (feet):

Depth to Water (feet):
Final Depth to Water (feet):
Height of Water Column (feet):

Purge Start Time:
Purge End Time:
Discharge Rate (gal/min):

Time	Volume	DTW	Temp.	pH	EC	D.O.	Redox	Turbidity	Visual Observation	Sample No.
(min/hours)	(gal)	(ft)	(°C)	(pH)	(μS/cm)	(mg/L)	(mV)	(NTU)		

ANALYSES REQUIRED	CONTAINER TYPE	FILTRATION?
VOC 8260B	**3-40ml VOA**	
8270	**2 - 1 liter ambers**	

Sample ID: ____________
QA/QC: ____________
QA/QC Sample ID and Time: ____________

FIELD OBSERVATIONS (Well condition, repairs needed)

Purge water disposal: poly tank storage/pump into City of Phoeinx Sanitary Sewer system
Sample collected with: Bailer_____ Pump _x__

Other notes:

DTW = Depth to water

Sampler Signature(s) :

OU-3 Daily Log

Personnel: _____ **Date:** _____

Weather: _____ **Project:** 96498.000

Time:	**Activities**

ERM-WEST EQUIPMENT CALIBRATION RECORD

(Per Manufacturer's Instructions)

NAME OF MANUFACTURER:				
MODEL:				
SERIAL NUMBER:				
CALIBRATION GAS OR STANDARD:				
DATE	**CALIBRATED BY**	**STANDARD (±)**	**READING**	**INITIALS**

Environmental Resources Management

CHAIN OF CUSTODY RECORD

NO: 1921

7272 E. Indian School Road, Suite 100 • Scottsdale, AZ • 85251 • (480) 998-2401 • FAX (480) 998-2106

Page _____ of _____

PROJECT #	PROJECT NAME

SAMPLER: **(PRINT NAME)**	**(SIGNATURE)**

RECEIVING LABORATORY

SAMPLE I.D.	DATE	TIME	COMP	GRAB	SAMPLING METHOD	PRESER-VATIVE	ICE (Y/N)	SAMPLING VOLUME	# OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	MATRIX: GAS	REQUESTED PARAMETERS										

RELINQUISHED BY ***(SIGNATURE)***	DATE	TIME	RECEIVED BY	DATE	TIME
RELINQUISHED BY ***(SIGNATURE)***	DATE	TIME	RECEIVED BY	DATE	TIME
RELINQUISHED BY ***(SIGNATURE)***	DATE	TIME	RECEIVED BY	DATE	TIME

FIELD REMARKS

REMARKS ON SAMPLE RECEIPT	ERM REMARKS
☐ BOTTLE INTACT ☐ CUSTODY SEALS ☐ CHILLED ☐ PRESERVED ☐ SEALS INTACT ☐ SEE REMARKS	

SEND REPORT TO:

WHITE – LABORATORY COPY CANARY – FIELD COPY PINK – DATABASE GOLD – PROJECT FILE

OU3
Motorla 52nd St Superfund Site
Ground Water Sampling
Field Notes / ERM

Date:
Set up time:
Weather:
Field Staff:

WELL #

Location: OU3 - Superfund Site
Construction:

Construction Depth (feet):
Screened Interval (feet):
Pump Intake Depth (feet):

Intake cycle (sec):
Discharge cycle (sec):
Purge/Sample Pressure (psi):

Depth to Water (feet):
Final Depth to Water (feet):
Height of Water Column (feet):

Purge Start Time:
Purge End Time:
Discharge Rate (gal/min):

Time	Volume	Temp.	pH	EC	D.O.	Redox	Turbidity	Visual Observation
(min)	(gal)	(°C)	(pH)	(µS/cm)	(mg/L)	(mV)	(NTU)	

ANALYSES REQUIRED	SAMPLE TIME	CONTAINER TYPE	FILTRATION?
VOC 8260B		**3-40ml VOA**	
8270		**2 - 1 liter ambers**	

Sample ID: _____
QA/QC: _____
QA/QC Sample ID and Time: _____

FIELD OBSERVATIONS (Well condition, repairs needed)

Purge water disposal: poly tank storage/pump into treatment system

Sample collected with: Bailer_____ Pump _x_

Other notes:

If it is necessary to purge with a disposable bailer, use the following equation to determine the total volume to be removed: lineal feet. x .653 gals./ft. x 3 = ____Gallons

Sampler Signature(s) :

OU3
Motorla 52nd St Superfund Site
Aquifer Testing - Slug Test
Field Notes / ERM

Date:
Set up time:
Weather:
Field Staff:

WELL #

Location: OU3 - Superfund Site
Construction:

Construction Depth (feet):
Screened Interval (feet):
Equipment Manufacturer:
Depth pressure transducer set at:

Slug construction Details:
Length (ft)
Width (in)
Weight (lbs)
Material:

Slug Test Set-up	Falling Head	Rising Head
Initial Depth to Water (feet):		
Final Depth to Water (feet):		
Height of Water Column (feet):		

Time (sec)	Depth to Water (ft)	Visual Observation	Comments

FIELD OBSERVATIONS (Well condition, repairs needed)

Other notes:

Sampler Signature(s) :

SOIL VAPOR WELL SAMPLING

Project Name: OU3
Project Number:
Date:
Field Staff:

WELL

Well Port	Purge Start Time	Sample Time	Pressure (inches-H_2O)	Flow Rate (ml/min)	Well Volumes Removed	Sample Collected
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag
						Summa/Tedlar Bag

A Shallow
B Intermediate shallow
C Intermediate deep
D Deep

ANALYSES REQUIRED	SAMPLE TIME	CONTAINER TYPE
TO-15		Summa/Tedlar Bag

Sample ID: _____
QA/QC: _____
QA/QC Sample ID and Time: _____

FIELD OBSERVATIONS (Well condition, repairs needed):

SUBCONTRACTOR QUALITY CONTROL REPORT

CONTRACT NO.	TITLE AND LOCATION	DATE	REPORT NO.

PREPARATORY PHASE	PLANS/SPECS REVIEWED	☐ YES	☐ NO	
	SUBMITTALS APPROVED	☐ YES	☐ NO	
	MATERIALS COMPLY WITH SUBMITTAL	☐ YES	☐ NO	
	MATERIALS STORED PROPERLY	☐ YES	☐ NO	
	PRELIMINARY WORK DONE PROPERLY	☐ YES	☐ NO	
	TESTING PLAN REVIEWED	☐ YES	☐ NO	
	WORK METHODS/SCHEDULE DISCUSSED	☐ YES	☐ NO	
	JSA ADDRESSED	☐ YES	☐ NO	

DEFINABLE FEATURE OF WORK, LOCATION, LIST OF PERSONNEL:			

INITIAL PHASE	PRELIMINARY WORK DONE CORRECTLY	☐ YES	☐ NO	
	SAMPLES PREPARED/APPROVED	☐ YES	☐ NO	
	WORKMANSHIP SATISFACTORY	☐ YES	☐ NO	
	TEST RESULTS ACCEPTABLE	☐ YES	☐ NO	
	WORK IN COMPLIANCE WITH CONTRACT	☐ YES	☐ NO	
	WORK COMPLIES WITH SAFETY RULES	☐ YES	☐ NO	

DEFINABLE FEATURE OF WORK, LOCATION, LIST OF PERSONNEL:			TESTS PERFORMED AND BY WHOM:

FOLLOW-UP PHASE	WORK COMPLIES WITH CONTRACT	☐ YES	☐ NO	
	WORK COMPLIES WITH SAFETY RULES	☐ YES	☐ NO	

DEFINABLE FEATURE OF WORK, LOCATION, LIST OF PERSONNEL:			TESTS PERFORMED AND BY WHOM:

REWORK ITEMS IDENTIFIED TODAY BUT NOT CORRECTED BY CLOSE OF BUSINESS:

REWORK ITEMS CORRECTED TODAY

REMARKS

AUTHORIZED QC OFFICER ON SITE DATE

SUBCONTRACTOR PRODUCTION REPORT

CONTRACT NO.	TITLE AND LOCATION	DATE	REPORT NO.

CONTRACTOR:	SUPERINTENDENT		

AM WEATHER	PM WEATHER	MIN TEMP	MAX TEMP

	WORK PERFORMED TODAY:		

ACTIVITY	WORK LOCATION AND DESCRIPTION:	EMPLOYER	NUMBER	TRADE	HOURS
				HRS WORKED THIS DAY	
				HRS FROM PREVIOUS REPORT	
				TOTAL HRS FROM START	

WAS A JOB SAFETY MEETING HELD THIS DATE? ☐ YES ☐ NO
ANY LOST TIME ACCIDENTS THIS DATE? ☐ YES ☐ NO
ANY CRANE/MANLIFT/TRENCHING/ELECTRICAL/HIGHWORK DONE? ☐ YES ☐ NO
ANY HAZARDOUS MATERIALS RELEASED INTO THE ENVIRONMENT? ☐ YES ☐ NO
IF YES TO ANY, ATTACH ADDITIONAL INFORMATION/REPORTS/FORMS

LIST SAFETY ACTIONS TAKEN TODAY/SAFETY INSPECTIONS CONDUCTED:

EQUIPMENT/MATERIALS RECEIVED TODAY TO BE INCORPORATED INTO JOB:

CONSTRUCTION/PLANT EQUIPMENT ON SITE TODAY (INCLUDE NUMBER HOURS USED)

REMARKS:

CONTRACTOR/SUPERINTENDENT DATE

Well Development / Purge Form

Project		Total Depth	Depth. Ind. S/N
Project No.		Depth to Water	Weather
Location		Water Column (ft. h.)	
Date		Casing Volume (gal) (2″ = 0.16h, 4″ = 0.66h)	
Well Number		Borehole Volume (gal) (2″ = 0.73h, 4″ = 1.15h)	
Method		Total Gallons Removed	
Field Personnel		Sample Number & Time	

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Appendix B
Interim Guidance for Active Soil Gas Investigations

Notice Required by ARS § 41-1091(B):
"This substantive policy statement is advisory only. A substantive policy statement does not include internal procedural documents that only affect the internal procedures of the agency and does not impose additional requirements or penalties on regulated parties or include confidential information or rules made in accordance with the Arizona Administrative Procedure Act. If you believe that this substantive policy statement does impose additional requirements or penalties on regulated parties you may petition the agency under A.R.S. § 41-1033 for a review of the statement."

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

SOIL VAPOR SAMPLING GUIDANCE

July 10, 2008

Soil Vapor Sampling Guidance

1. Scope and Application

2. Definitions

3. Considerations When Planning for Soil Vapor Sampling
3.1 Temporal Variations in Soil Vapor Concentrations
3.2 Conditions Unsuitable for Collection of Soil Vapor Samples
3.3 Tests to Determine if Soil Vapor Sampling is Practicable
3.4 Confirmation Sampling

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4.2 Permanent Probes
4.3 Equilibration Time

5. Sampling and Analysis
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6. Relating Soil Vapor Concentration to Total Soil Concentration
6.1 Three-phase Partitioning Equation
6.2 List of Default Values for Soil Matrix
6.3 Test Methods Required to Change Soil Matrix Default Values
6.4 List of Chemical Default Values (K_{oc} and H_o) for Selected VOCs

7. Procedure References

Disclaimer: Please note that the information is intended as general guidelines and not specific recommendations for all sites. Site-specific considerations, professional judgment, and regulatory requirements will dictate the methods and procedures used at any particular site.

Soil Vapor Sampling Guidance

1. Scope and Application

1.1 This guidance describes procedures for collection of active soil vapor samples and does not address procedures for collection of passive soil vapor samples.

1.2 This guidance is intended to detail sampling procedures to ensure delivery of soil vapor samples to the laboratory that will yield reliable and consistent results that are representative of actual conditions.

2. Definitions

2.1 Dead Volume – volume of the sampling probe and the connected sampling tubing and equipment. The boring volume is not included in the calculation of dead volume, because the probe tip sand-pack space is assumed to have been allowed to equilibrate with surrounding soil formation before soil vapor sampling occurs.

2.2 Internal Volume – dead volume plus probe tip sand-pack volume.

2.3 Probe Driving System – hydraulic or hammer system used for installation of soil vapor sampling probes.

2.4 Soil Vapor Monitoring Well – a well constructed specifically to sample soil vapor from the vadose zone.

2.5 Soil Vapor Sample – a sample of soil vapor representative of the vadose zone at the sampled location.

2.6 Soil Vapor Sampling Port – any mechanical device (usually a ball valve with a hose barb) that allows a representative soil vapor sample to be collected from a soil vapor monitoring well.

2.7 Soil Vapor Sampling Probe – any mechanical device that allows a representative sample of soil vapor to be collected from specified sampling depth.

2.8 Vapor Equilibration – the condition where vapor concentration entering a sampling probe is 95% or greater of vapor concentration in surrounding soil.

3. Considerations when Planning for Soil Vapor Sampling

The collection and analysis of soil vapor samples, along with any existing soil and groundwater data or any reasonably obtainable data (e.g., soil solids and groundwater

data), is useful for the objectives of site characterization, determination of potential pathways of exposure for health risk, optimization of remedial or mitigation systems design, and confirmation of compliance with remedial goals.

3.1 Temporal Variations in Soil Vapor Concentrations

Variations in soil vapor concentrations due to temporal effects are principally due to temperature changes, precipitation, and activities within any overlying structure. Variations will be greater the closer the samples are to the surface and are lessened with increasing depth. There are a number of available studies on the temporal variation in soil vapor concentrations and more are currently underway or planned in 2007 by the EPA and independent groups. The results of these studies have shown that short-term variations in soil vapor concentrations at depths four feet or deeper are less than a factor of two and seasonal variations in colder climates less that a factor of five.

Larger variations in soil vapor concentrations may be expected in areas of greater temperature variation and during periods of heavy precipitation as described below.

· Temperature: Effects on soil vapor concentrations due to actual changes in the vadose zone temperature will be minimal.

· Precipitation: Infiltration from rainfall can potentially impact soil vapor concentrations by displacing the soil vapor, dissolving volatile organic compounds, and by creating a “cap” above the soil vapor. In most settings, infiltration from large storms only penetrates into the uppermost vadose zone. Soil vapor samples collected at depths greater than 3 to 5 feet below ground surface (bgs) under foundations or areas with surface cover are unlikely to be significantly affected. However, soil vapor samples collected closer to the surface (<3 feet) with no surface cover may be affected. If the moisture has penetrated to the sampling zone, it typically can be recognized by difficulty in collecting soil vapor samples. If high vacuum readings are encountered when collecting a sample, or drops of moisture are evident in the sampling system or sample, measured values should be considered as minimum values. Measurement of percent moisture of the soil may also be useful if shallow sampling is performed during or shortly after significant rainfall (>1.0 inch).

· Pressure: Barometric pressure variations are unlikely to have a significant effect on soil vapor concentrations at depths exceeding three to five feet bgs and only a minor effect (less than a factor of 2) at shallower depths unless a major storm front is passing through the area. A recent study in Wyoming (Luo et al., 2006) has shown little to no relationship between barometric pressure and soil vapor oxygen concentrations.

Human induced influences to pressure are likely to have a bigger effect upon soil vapor concentrations. For example, pressure changes resulting from the on-off cycling of an overlying building’s heating or HVAC system and the ventilation of the structure due to open doors and windows can greatly influence soil vapor concentrations at locations near the building. In colder climates, greater impacts are most likely in the winter season.

Literature suggests that temporal variations in the radon concentrations are typically less than a factor of two and seasonal effects less than a factor of five. (Vapor Intrusion Pathway: A Practical Guideline, January 2007 Interstate Technology and Regulatory Council)

3.2 Conditions Unsuitable for Collection of Soil Vapor Samples

3.2.1 Soil vapor samples should not be collected if:

a. The groundwater is very close to the ground surface (i.e., < 3 feet);

b. Chemical(s) of concern is/are not volatile; and

c. Moisture or unknown material is observed in the sample stream or sample container.

Please note that due to increased diffusivity, advective flow, and temperature fluctuations at near surface boundaries, the collection of a soil vapor sample in near surface soils is not useful for the purpose of calculating total soil solid VOC concentrations.

3.3 Tests to Determine if Soil Vapor Sampling is Practicable

Some soil types (i.e., clay or silty clays) may not be conducive for soil vapor collection. Tests to ascertain if soil vapor can be collected from the soils are outlined below.

3.3.1 As a qualitative test, a gas-tight syringe could be connected to the soil-vapor-sampling tubing to determine if a sample can be withdrawn. Please note that the soil-vapor-sampling tubing must have a volume of less than the gas-tight syringe for a meaningful result.

3.3.2 Another test that can be performed to determine if soil vapor sampling is practicable at a site is as follows:

a. Install a T-connection at the end of the soil-vapor-sampling tubing;
b. Connect a vacuum gauge to one branch of the T-connection;
c. Connect a syringe fitting and a 60-mL or larger syringe to the remaining branch of the T-connector;
d. With the syringe connected, pull the plunger back to the full-scale reading and hold in that position; and then
e. Monitor the vacuum created at the full draw position and during relaxation.

If the vacuum does not relax within a few minutes to an hour, it is unlikely that soil vapor sampling is practicable at that particular location and other locations in the subsurface with similar soil characteristics.

3.4 Confirmation sampling

Soil vapor samples used to verify completion of remedial actions must verify that residual contaminant concentrations are at or below the corrective action standard for each chemical of concern in the contaminated soil as determined under A.A.C. R18-7-201 *et seq*.(please refer to Section 6). The soil vapor samples must be collected throughout all areas previously reporting soil solid concentrations for chemicals of concern above applicable corrective action standards.

4. Installation Methods

This section provides useful construction information and details for installation methods.

4.1 Sample Through Rods (also known as temporary probes)

This method is advantageous if only one sampling round is required. Also, less material is placed in the ground, minimizing disturbance of the in-situ vapor and decreasing the need for collection of blanks.

The following construction details should be considered for the collection of a sample through rods:

a) Seal probes at the surface with bentonite before sampling;

b) Utilize small diameter rigid tubing (such as Teflon or Nylon) rather than flexible tubing (such as Tygon, and both low and high density polyethylene) when sampling VOCs, due to flexible tubing's tendency to leak and significant adsorption/losses seen when using this material; and

c) When using direct-push borings for the installation of soil-vapor-sampling probes, avoid lateral movement of the probes once they are in the ground to prevent atmospheric air from entering the sampling system.

4.2 Permanent Probes

The following construction details should be considered for the installation of permanent probes:

a. Use short discreet sampling intervals (e.g., 6 to 12 inches);

b. Color code or tag tubing of probes at the surface to be sure that the sampling depth is easily identifiable for future sampling events;

c. Complete and seal permanent probes at the ground surface (e.g., road boxes, locked caps, vapor-tight valves).

When using auger, air rotary, or rotosonic drilling methods for the installation of soil-vapor sampling probes, the following should be considered:

a. Install sampling probes with sand-pack intervals of approximately 1 foot;

b. Seal each sampling interval with bentonite or grout above and below the sand pack in the annulus of the boring. Care should be taken to ensure that the seal material does not intrude into the sand pack;

c. If dry bentonite is placed in the boring, care should be taken to fully hydrate the bentonite. Placing the bentonite in small increments (e.g., < 6 inches) followed by water is helpful. Alternatively, the bentonite can be added using a combination of dry and hydrated bentonite, or in slurry form if the boring is of sufficient diameter; and

d. For deeper probes, down-hole support rods may be necessary during probe installation, especially for tubing sized greater than 1/8-inch OD..

4.3 Equilibration Time

During probe installation, subsurface conditions are disturbed. For probes installed with hollow stem, air rotary, or rotosonic drilling methods, purge volume test, leak test and soil vapor sampling should not be conducted for at least 48 hours (depending on site lithologic conditions and stage of investigation) following probe installation. When utilizing sample through rods, a 20 to 30 minute equilibration time is recommended.

5. Sampling and Analysis

5.1 Sampling Containers

The sample containers chosen for a specific site will depend on the sampling equipment and analytical requirements. The ultimate storage container should be selected prior to the initial sampling.

5.1.1 Examples of different sample containers include:

a. Tedlar™ bags;

b. Stainless steel canisters (e.g., Summa™canisters); and

c. Gas-tight syringes

All of the above listed sample containers are relatively simple to fill. Tedlar™ bags have a 72 hour holding time. Stainless steel canisters have a 30 day holding time. Syringes are typically utilized for on site analysis and the holding time should be as short as possible (less than 5 minutes for plastic syringes and less than 15 minutes for glass syringes). The transferring of samples to different container types for the purpose of extending holding times is not recommended.

5.1.2 Storage and Shipping Considerations

a. Do not put sample on ice;

b. Do not store sample exposed to light (keep sample in dark place); and

c. Keep sample at standard temperature and pressure as much as practicable.

d. Tedlar samples are not to be shipped by airplane.

5.2 <u>Sample Collection</u>

5.2.1 Sample Collection Flow Rates

Flow rates should not exceed approximately 100 - 200 ml/min and vacuums should be maintained to below 10 inches of water, if practical. Also, consider the following:

a. Minimizing the sample collection flow rate for near groundwater situations to prevent groundwater from entering the sample container;

b. Measuring and recording the vacuum at which the samples were collected for each sampling probe;

c. Monitoring the vacuum during sampling with an in-line gauge; and

d. Use of a calibrated flow controller supplied by the lab to provide a consistent flow rate for each sample collected. One flow controller should be used for each sample collected.

5.2.2 Sample Collection Procedure

The following are examples of sample collection procedures utilizing different types of sample containers:

a. Collection using Tedlar™ bags:

    1. A “T-coupling” should be used to place the Tedlar™ bag in the sampling system ahead of the purging equipment used to purge vapor from the

system. Appropriate compatible connecting threads will be required in order to use the Tedlar™ bag;

2. Attach sample tubing to a vacuum box and pump;

3. Label the bag accordingly and keep it in a dark area with the temperature as near as possible to the soil temperature at the time sampled (to avoid condensation) as much as practicable until analysis occurs. The sample collected in a Tedlar™ bag should be analyzed as soon as possible after collection;

4. Open the valve on a clean dry Tedlar™ bag and attach it to the inside of the vacuum box;

5. Close the vacuum box, close stopcock (3-way valve) between vacuum box and pump, then turn the pump on; and

6. Allow Tedlar™ bag to fill to 50 – 70% of capacity (do not overfill), shut off the pump, close the toggle switch (to prevent loss of sample), open the stopcock, and remove Tedlar™ bag from the vacuum box.

b. Collection using stainless steel canisters (e.g., Summa™ canisters):

1. Prior to sampling, check with the laboratory regarding canister post sampling vacuum requirements. Laboratories may require certain residual vacuum in the canister to conduct laboratory QA/QC procedures.

2. A “T-coupling” should be used to place the stainless steel canister in the sampling system ahead of the purging equipment used to purge vapor from the system. Appropriate compatible connecting threads will be required in order to use the stainless steel canisters;

3. A manometer (or similar type of vacuum gauge) should be used to verify that the stainless steel canister, used in the field, arrived from the laboratory with the proper vacuum, stainless steel canisters must also arrive from the laboratory with certification indicating that the canisters have been properly pre-cleaned and evacuated. Empty stainless steel canisters may not be stored for more than 30 days prior to sample collection. Once filled, the stainless steel canisters should be properly labeled and packaged for transport to the off-site laboratory. (Note: Only stainless steel canisters can be shipped by air freight to an analytical laboratory for analysis and should be analyzed within 30 days after sample collection.);

4. Open the stainless steel canister valve by rotating it counter-clockwise 1-2 rotations. You may hear soil vapor rushing (hissing sound) into the canister;

5. Allow the canister to equilibrate for 30-60 seconds and close the valve (hand tighten, over tightening may result in leakage and loss of sample);

6. Close the sampling port ball valve (open the valve all the way then close it down) then remove the sampling line from the sampling port and the canister;

7. Attach the vacuum pressure gauge to the canister. Check and record the vacuum pressure. It is recommended that for monitoring/confirming canister pressures not to rely on analog style gauges that a laboratory may provide;

8. Remove the vacuum pressure gauge and replace the canister valve cap; and

9. Complete the sample label (Note: Labeling should be done on the tag attached to the canister), do not write on the outside of the stainless steel canister itself.

5.3 Analysis

Analysis of vapor samples can occur in the field (mobile laboratory) or at a fixed laboratory setting. Use of a mobile laboratory for vapor analyses can be practical in terms of data collection when field decisions need to be made, especially during the investigative process. The intention of analyses in the field is to ensure a good data set that provides results in real time that adequately represents conditions at the site. A good field data set should result in less time spent during the site investigation process.

The following analytical methods are acceptable for soil vapor analysis:

For VOCs:

a. 8260B (Modified for Vapor)
b. 8021B (Modified for Vapor)
c. TO-15

5.4 Data Quality Objectives (DQOs)

Data quality objectives (DQOs) will vary with both the stage of investigation and the intended use of the data collected from soil vapor sampling. During screening or the initial stages of investigation, DQOs will be less stringent than those for confirmation of remediation or risk assessment for indoor air vapor intrusion. DQOs will determine the sampling method, the type of sample collected, the frequency of sample collection,

sampling location, the number of samples to be collected, and the specific quality assurance (QA) and quality control (QC) necessary, both in the field as well as in the laboratory. Following DQOs will ensure that the data is useable for the intended purpose.

The most important QA/QC activities and parameters include:

a. Sampling method
b Sampling equipment maintenance and calibration
c. Control samples, i.e., trip blanks, field blanks, method blanks
d. Standard Operation Procedures (SOPs)
e. Analyses method appropriate for target compounds
f. Sample holding times and transportation conditions
g. Analyses method with required practical quantitation level
h. Laboratory QC samples

5.5 Quality Assurance/Quality Control

5.5.1 Sampling QA/QC

Solid quality assurance and quality control procedures start with organized planning. A well thought out work plan will help to ensure that soil vapor samples are collected in a manner resulting in data of known quality. Stated data objectives and quality control techniques are essential to the work plan. There are several quality control procedures to ensure collection of representative samples. The following are some of those quality control procedures that should be considered:

a. Purging

Purging is utilized to obtain a sample that represents equilibrated vapor concentrations of soil surrounding the sampling probe. The initial purge testing should be conducted in an area where positive detections are most likely to occur. The purged volume selected should be consistent for all sample locations across the site. Please consider the following procedure with respect to purging:

1) Remove three to five internal volumes of a sample system. This should ensure that vapor concentration entering a sampling container is 95% or greater representation of vapor concentration in surrounding soil; or

2) If vapor equilibration has occurred, remove one to five dead volumes;

The number of dead volumes requiring removal may be based on procedures such as:

3) Analyzing the purged vapor with a field vapor analyzer (PID or FID) until the concentrations of total hydrocarbons stabilize, or use field instruments to measure respiration gases (e.g., O2, CO2) and assess consistency across sequential purged volume samples; or

4) Conducting a purged volume test to determine the number of dead volumes to remove that corresponds to the highest recovered vapor concentrations.

Please note that care should be taken not to collect a sample under non-equilibrium conditions generated by high purge rates.

b. Leak Testing

Consider conducting a leak test where leakage may be a concern (e.g., shallow sample intervals, large sample volumes).

The following is a procedure for checking belowground sampling equipment for leaks:

1) Use oxygen as a qualitative test for a high-end indicator of short-circuiting. Elevated oxygen measurements in soil vapor analytical results may indicate significant short-circuiting. This, though, may not be true for shallow depths or in areas where there is only halogenated VOC contamination); and

2) Use tracer compounds (e.g., helium, butane, propane, isopropanol) to conduct leak tests (helium is recommended as a leak tracer for projects using TO-15 (fixed lab) analysis). For example, the tracer is applied at the surface where air could enter the soil vapor probes. When using a tracer gas, a shroud is needed to keep the tracer gas in contact with the probe during the testing.

   The soil vapor sample is analyzed for the tracer compound using a method that can achieve less than 10 µg/L detection limit. Care should be taken that the tracer compound of interest and other co-existing volatile compounds in the tracer media are not target compounds of interest in soil vapors investigated at the site. A discussion of advantages and disadvantages regarding different tracers can be found in Appendix D (pages D-9 and 10) of the January 2007 ITRC Vapor Intrusion Pathway: A Practical Guideline.

Leak testing of the sampling train (aboveground sampling equipment) may be performed by a variety of methods:

1) Use tracer compounds as described above; or

2) Use a vacuum test where the system is closed, a vacuum applied, and the vacuum is observed over a period time to ascertain if there are system leaks.

c. Decontaminating Aboveground Equipment

Clean aboveground sampling equipment should be used for all parts of the soil vapor sample collection. This can be implemented by using disposable parts, or using proper procedures to clean reusable equipment. Please consider the following:

1) External sampling equipment parts should be washed in the field between samples if reused; and

2) Tubing should not be re-used for samples where lower concentrations are expected once it has been used to collect samples where higher concentrations are expected.

5.5.2 Analysis QA/QC

All soil vapor analysis should be performed by a laboratory that is certified by Arizona Department of Health Services (ADHS) and maintains a Quality Assurance Plan. Quality Control Procedures for analysis performed with soil vapor sampling should follow good laboratory practices and criteria within the specified methods and at a minimum include the following quality control criteria:

a. Detection Limit Study
b. Method Blank
c. Calibration
d. Calibration Verification
e. Surrogates
f. Duplicate
g. Second Source Standard

When QC criteria fall outside specified control limits, the analysis should be qualified using Arizona data qualifiers. Any event that cannot be described by the data qualifiers must be documented in a case narrative which must be included with the final report. Using the Arizona data qualifiers does not automatically qualify the data as acceptable to ADEQ. ADEQ expects that data reported utilizing these qualifiers, unless stated otherwise, is useable, scientifically valid and defensible.

5.5.3 Other Soil Vapor Analytes

Chemicals of interest for soil vapor sampling are specific for the type of contaminant release and breakdown products. They include both volatile organic and inorganic compounds, as well as some semi-volatile organic compounds. The method selected for laboratory analysis should be consistent with the stage of investigation and remediation, the volume of sample that is practical to collect, and the DQO's. Analysis

of all samples collected to demonstrate compliance with regulatory requirements should be conducted by a laboratory licensed by the ADHS using an ADHS approved method.

The following table lists the types of compounds, methods, and ADHS approval status. The laboratory should be consulted for specific target list compounds, as well as detection limits. If a particular method is desired for compliance sampling which is not currently approved by ADHS, please contact ADEQ to begin approval for the method using A.A.C. R9-14-610(C).

Table 5.1 Analytical Methods

Compounds	**Method**	**ADHS Certified**
Chlorinated VOCs and Petroleum VOCs BTEX/MTBE	TO-14A	Yes
Chlorinated VOCs and Petroleum VOCs	TO-15	Yes
VOCs	8260	*
VOCs	8021	No

*** - ADHS has begun the working on the process for certifying Method 8260**

6. Relating Soil Vapor Concentration to Total Soil Concentration

Calculation of total soil concentrations using the method outlined below will vary depending on the input choice of chemical and physical values, such as soil adsorption coefficients (K_{oc}) and soil organic carbon fractions (f_{oc}). In this section, ADEQ provides a list of default values and methods to derive alternative values to be utilized in the three-phase partitioning equation outlined in Section 6.1. The listed default values are appropriate for use throughout much of Arizona and are conservative values so as to be protective of public health and the environment.

6.1 Three-phase Partitioning Equation

The following three-phase partitioning equation is accepted by ADEQ for the calculation of total soil concentrations which may occur in situ for a chemical. The equation is based on a standard soil partitioning equilibrium model which assumes that a fourth phase, non-aqueous phase liquid (NAPL) is not present. Therefore, at soil concentrations exceeding the 3-phase saturation limit, measured soil vapor concentrations are inapplicable for calculating total soil concentrations using this equation. The equations used that govern the equilibrium partitioning between phases are the linear sorption partitioning equation normalized with respect to organic carbon (Karichoff et al., 1979) and Henry's Law:

$$C_t = \frac{C_g\,[K_{oc} f_{oc} \rho_b / H_o + \theta_w / H_o + (\theta_t - \theta_w)]}{\rho_b}$$

where,

C_t – Total concentration in soil (µg/kg)

C_g – Concentration in soil vapor (µg/L)

f_{oc} – Mass fraction of natural soil organic carbon content (g-organic carbon/g-soil)

K_{oc} – Soil organic carbon-water partitioning coefficient (ml/g)

ρ_b – Dry Bulk Density (kg/L)

H_o – Henry's Law Constant (dimensionless)

θ_t – Total soil porosity (volume of voids/volume total)

θ_w – Volumetric Water Content (volume of water/volume of soil)

6.2 List of Default Values for the Soil Matrix

Fraction of Organic Carbon in Soil (f_{oc}). A default input for fraction of organic carbon in soil of 0.006 (0.6%) is selected for use in the equation.

Soil Dry Bulk Density (ρ_b). A default input for dry bulk soil density of 1.5 kg/L is selected for use in the equation. Dry bulk-densities for basin-fill deposits typically range from 1.3 to 1.8 kg/L. The 1.5 kg/L value is within this range.

Total Soil Porosity (θ_t). A total soil porosity of 0.43 (43%) is selected is selected for use in the equation and was based on a default soil particle density (ρ_s) of 2.65 kg/L [$\theta_t = 1 - \rho_b/\rho_s = 0.43$].

Soil Volumetric Water Content (θ_w). A default volumetric water content of 15% (0.15) is selected for use in the equation. Volumetric water content in basin-fill deposits typically range from 5 to 25 percent. The 15% value is within this range.

6.3 Test Methods Required to Change Soil Matrix Default Values

This section specifies procedures and requirements to derive site-specific input parameters for use in the three-phase partitioning equation. Site-specific values may be substituted for one or more of the following four input parameters: soil dry bulk density, soil organic carbon content, total soil porosity, and soil volumetric water content.

Deriving soil organic carbon fraction (f_{oc}). ASTM Method D2974 or other methods approved by ADEQ may be used to derive site-specific soil organic carbon fraction values. Soil samples used to measure site-specific soil organic carbon content must be

collected from uncontaminated soil in lithologic zones that are representative of where the soil-vapor contamination is present. All laboratory measurements shall be based on methods that do not include inorganic carbon in the measurements.

Deriving soil dry bulk density (ρ_b). ASTM Method D2049 or D2937 or other methods approved by ADEQ may be used to derive site-specific soil bulk density values.

Deriving total soil porosity (θ_t). ASTM Method D4404 or other methods approved by ADEQ may be used to derive site-specific total soil porosity values.

Deriving soil volumetric water content (θ_w). ASTM Method D2216 or other methods approved by ADEQ may be used to derive soil volumetric water content values.

6.4 List of Chemical Default Values (K_{oc} and H_o) for Selected VOCs

Soil organic carbon-water partitioning coefficients (K_{oc}) and dimensionless Henry's Law constants (H_o) are provided for the following VOCs (see table below). These values, taken from *Soil Screening Guidance* (US EPA, 1996), are accepted by ADEQ for use in the three-phase partitioning equation. The chemicals shown are not a complete list of all potential VOCs encountered in contaminant releases, but represent those commonly encountered, those with greater potential to exist in the vapor phase, or those with greater toxicity relative to other VOCs.

Alternative K_{oc} and H_o values can be substituted for the values listed in the table below if those alternative values more accurately represent conditions encountered at a site. Sources for these values may be obtained from the *Superfund Chemical Data Matrix* (US EPA, most current editions) and the most recent version of Estimation Programs Interface Suite™ (US EPA, 2007) available at http://www.epa.gov/opptintr/exposure/pubs/episuite.htm. Alternative K_{oc} and H_o values based on scientific literature are subject to ADEQ approval.

Compound	K_{oc} (L/kg)[1]	H_o (dimensionless)[2]
Benzene	5.89E+01	2.28E-01
Bromodichloromethane	5.50E+01	6.56E-02
Bromoform	8.71E+01	2.19E-02
Carbon disulfide	4.57E+01	1.24E+00
Carbon tetrachloride	1.74E+02	1.25E+00
Chlorobenzene	2.19E+02	1.52E-01
Chloroform	3.98E+01	1.50E-01
1,2-Dibromoethane (EDB)	2.81E+01	2.90E-02
1,1-Dichloroethane	3.16E+01	2.30E-01
1,2-Dichloroethane (DCA)	1.74E+01	4.01E-02
1,1-Dichloroethene	5.89E+01	1.07E+00
cis-1,2Dichloroethene	3.55E+01	1.67E-01
trans-1,2=Dichloroethene	5.25E+01	3.85E-01
1,2-Dichloropropane	4.37E+01	1.15E-01
1,3-Dichloropropene	4.57E+01	7.26E-01
Ethyl benzene	3.63E+02	3.23E-01
Methyl bromide	1.05E+01	2.56E-01
Methylene chloride	1.17E+01	8.98E-02
Styrene	7.76E+02	1.13E-01
1,1,2,2-Tetrachloroethane	9.33E+01	1.41E-02
Tetrachloroethene (PCE)	1.55E+02	7.54E-01
Toluene	1.82E+02	2.72E-01
1,1,1-Trichloroethane	1.10E+02	7.05E-01
1,1,2-Trichlorethane	5.01E+01	3.74E-02
Trichloroethene (TCE)	1.66E+02	4.22E-01
1,2,4-Trimethylbenzene	3.72E+03	2.30E-01
1,3,5-Trimethylbenzene	8.19E+02	3.20E-01
Vinyl acetate	5.25E+00	2.10E-02
Vinyl chloride	1.86E+01	1.11E+00
Xylenes (total)[3]	3.86E+02	2.76E-01

Ref: U.S. EPA Soil Screening Guidance: User's Guide, 2nd Edition (July 1996)

[1] - K_{oc} = organic carbon partition coefficient

[2] - H_o = Dimensionless Henry's Law Constant (HLC[atm-m]*41(25°C))

[3] – K_{oc} and F_{oc} values for total Xylenes represent average of values for *ortho*-, *meta*-, and *para*-Xylenes.

A soil vapor unit conversion table is supplied below.

Soil Vapor Unit Conversion Factors*		
Unit	To Convert To:	Multiply by:
µg/L	mg/m^3	1
$\mu g/m^3$	mg/m^3	0.001
Ppbv	$\mu g/m^3$	MW/24
$\mu g/m^3$	Ppbv	24/MW
Ppmv	mg/m^3	MW/24
Ppbv	mg/m^3	MW/24,000
µg/L	$\mu g/m^3$	1000
$\mu g/m^3$	µg/L	0.001
µg/L	Ppbv	24,000/MW
µg/L	Ppmv	24/MW
Ppbv	Ppmv	0.001
Ppmv	Ppbv	1000

*At standard temperature and pressure.

µg/L	micrograms per liter
mg/m^3	milligrams per cubic meter
$\mu g/m^3$	micrograms per cubic meter
ppbv	parts per billion by volume
MW	molecular weight
ppmv	parts per million by volume

7. Procedure References

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STATE OF CALIFORNIA
California Regional Water Quality Control Board
Los Angeles Region

INTERIM GUIDANCE FOR ACTIVE SOIL GAS INVESTIGATION
(February 25, 1997)

Introduction

Volatile organic compounds (VOCs) within the unsaturated zone partition into the adsorbed, dissolved, free liquid, and vapor phases. Measurement of VOCs through an active soil gas investigation allows: 1) evaluation of whether waste discharges of VOCs have occurred which may impact groundwater, 2) determination of spatial pattern and extent of vapor phase soil contamination, 3) establishment of vapor distribution for the design of soil vapor extraction (SVE) system, and 4) determination of the efficiency of reduction in threat to groundwater from any cleanup action, including SVE. The work plan should include, but not be limited to, the following:

1.0 Survey Design

1.1
Provide a scaled facility map depicting potential sources and proposed sampling points. Include locations and coordinates of identifiable geographic landmarks (e.g., street center-line, benchmark, street intersection, wells, north arrow, property line).

1.2
Locate initial sampling points in potential source areas and areas with known soil contamination using an adjustable 10 to 20 foot grid pattern. Provide rationale for the number, location and depth of sampling points. Screen the remainder of the site with a 100-foot or less grid pattern.

1.3
Conduct a close interval (10 to 20 foot grid pattern) and multi-level sampling (5 to 10 feet vertical distance between points) in areas with known or relatively high VOC concentrations.

1.4
Use an on-site mobile laboratory with laboratory-grade certifiable instrumentation and procedures for real-time analysis of individual VOCs. Non-specific portable organic vapor analyzers and/or GC-based handheld detectors may not be used for analysis, except for daily or weekly vapor monitoring during SVE.

1.5
Maintain flexibility in the sampling plan such that field modifications (grid pattern density, location and depth) can be made as real-time evaluation of analytical test results occurs. Include in the work plan decision-making criteria for these adjustments and explain decisions in the report. Field decisions shall be made in consultation with Regional Board staff.

1.6
Re-sample at any sampling point if anomalous data (i.e., 2 to 3 orders of magnitude difference from surrounding samples) are obtained. Board staff may require additional points to resolve the spatial distribution of the contaminants within the interval in question.

2.0 Sample Collection

2.1
Obtain samples at an adequate depth (nominally 5 feet) below ground surface (bgs) to minimize potential dilution by ambient air.

2.2
Conduct a site-specific purge volume versus contaminant concentration test at the start of the initial soil gas survey and vapor monitoring well sampling. The purpose of the test is to purge ambient air in the sampling system with minimal disturbance of soil gas around the probe tip. Conduct this test based on soil type and where VOC concentrations are suspected to be highest. Describe specific method and equipment to determine optimal purge rates and volumes. Take into account the potential sorption of target compounds to the tubing and adjust the purge rate and time to achieve the optimal purge volume. Limit the sampling vacuum to collect proper samples. Optimum purge volume may be compound specific. "Lighter" early eluting VOCs, such as vinyl chloride, may reach their highest concentration with less purging than "heavier" late eluting VOCs like PCE. Therefore, optimize the purge volume for the compound(s) of greatest concern.

2.3
Explain the expected zone of influence for sample points, taking into consideration soil types, land cover, drive point construction and sample purge rate/time/volume. The vertical zone of influence for purging and sampling must not intersect the ground surface.

2.4

Discuss soil gas sample collection and handling procedures. Discuss the procedures to prevent collection of samples under partial vacuum and the methods to minimize equipment cross-contamination between sampling points.

2.5
Avoid making a pilot hole (e.g., using a slam bar) prior to inserting the probe rod, except to drill through asphalt or concrete. The process of making a pilot hole may promote vapor contaminant aeration and result in lower sample concentration.

2.6
Specify that the sampling equipment (e.g., gas tight syringe, sorbent trap) will not compromise the integrity of the samples. Tedlar bags may only be used for qualitative analysis.

2.7
Assure that the probe tip, probe and probe connectors have the same diameter to provide a good seal between the formation and the sampling assembly. If a space develops between the probe and the formation, as a result of probe advancement, seal (e.g., with bentonite) the area around the probe at the surface to minimize the potential for ambient air intrusion.

2.8
Some sampling systems (e.g., Geoprobe) utilize the probe rod as a conduit for the tubing that connects to the probe tip. Assure a tight fit between the tubing and probe tip to minimize potential for leakage and dilution of the sample.

2.9
Follow the sampling method specified in the soil gas consultant's standard operating procedure (SOP). Discuss with Board staff any deviations from the SOP before it is implemented in the field.

3.0 Laboratory Analysis of Soil Gas Samples

3.1 Primary Target Compounds

1. Carbon tetrachloride
2. Chloroethane
3. Chloroform
4. 1,1-Dichloroethane
5. 1,2-Dichloroethane
6. 1,1-Dichloroethene
7. cis-1,2-Dichloroethene
8. trans-1,2-Dichloroethene
9. Dichloromethane (methylene chloride)
10. Tetrachloroethene
11. 1,1,1,2-Tetrachloroethane
12. 1,1,2,2-Tetrachloroethane
13. 1,1,1-Trichloroethane
14. 1,1,2-Trichloroethane
15. Trichloroethene
16. Vinyl chloride
17. Benzene
18. Toluene
19. Ethylbenzene
20. Xylenes
21. Trichlorofluoromethane (Freon 11)
22. Dichlorodifluoromethane (Freon 12)
23. 1,1,2-Trichloro-trifluoroethane (Freon 113)

3.2 Other Target Compounds
Analyze for other VOCs (e.g., methyl ethyl ketone, methyl isobutyl ketone, ethylene dibromide, petroleum hydrocarbons, etc.) based upon site history and conditions.

3.3 Detection Limit (DL)
Attain a DL of not more than 1 µg/L for all target compounds. A higher DL is acceptable only for the compound(s) whose concentration exceeds the initial calibration range.

3.4 Detectors
Use the following detectors in appropriate combinations:

Electrolytic conductivity detector (ELCD) (e.g., Hall)
Photoionization detector (PID)

Flame ionization detector (FID)
Mass spectrometer (MS)
Electron capture detector (ECD)

3.5.0 Identification of Calibration Standards & Laboratory Control Sample (LCS)

3.5.1
Properly and clearly identify all calibration standards and LCS. The identification must agree with the data on record for the standards and LCS.

3.5.2
Prepare LCS from a second source standard that is totally independent from the standards used for the initial calibration. Second source means a different supplier (whenever possible) or a different lot from the same supplier.

3.6.0 GC Conditions

3.6.1
Use a type of column that can separate all the target compounds. Coelution of the target compounds is not acceptable unless the compounds are distinguished and quantified by two different types of detectors in use at that time.

3.6.2

Analyze the initial calibration and daily mid-point calibration check standards, LCS, blank, and samples using the same GC conditions (i.e., detector, temperature program, etc.).

3.6.3
Use a GC run time that is long enough to identify and quantify all the target compounds.

3.7.0 Initial Calibration (Record in Table 1)

3.7.1
Perform an initial calibration:

1. for all 23 compounds listed in Section 3.1;
2. when the GC column type is changed;
3. when the GC operating conditions have changed;
4. when the daily mid-point calibration check cannot meet the requirement in Section 3.8.3; and
5. when specified by Regional Board staff based on the scope and nature of the investigation.

3.7.2
Include at least three different concentrations of the standard in the initial calibration, with the lowest one not exceeding 5 times the DL for each compound.

3.7.3
Calculate the response factor (RF) for each compound and calibration concentration prior to analyzing any site samples. Calculate the average RF for each compound. The percent relative standard deviation (%RSD) for each target compound must not exceed 20% except for the following compounds which must not exceed 30%:

Trichlorofluoromethane (Freon 11)
Dichlorodifluoromethane (Freon 12)
Trichlorotrifluoromethane (Freon 113)
Chloroethane
Vinyl chloride

3.7.4
Verify the true concentration of the standard solutions used with the LCS after each initial calibration. Conduct the verification using a LCS with a mid-point concentration within the initial calibration range. The LCS must include all the target compounds. The RF of each compound must be within ±15% difference from the initial calibration, except for freon 11, 12 and 113, chloroethane, and vinyl chloride which must be within ±25% difference from the initial calibration.

3.8.0 Daily Mid-point Calibration Check (Record in Table 1)

3.8.1
Check the calibration using the calibration standard solution with a mid-point concentration within the linear range of the initial calibration before any sample is analyzed.

3.8.2
Include in the daily mid-point calibration check standard the following compounds and **every** compound expected or detected at the site:

1. 1,1-Dichloroethane
2. 1,2-Dichloroethane
3. 1,1-Dichloroethene
4. cis-1,2-Dichloroethene
5. trans-1,2-Dichloroethene
6. Tetrachloroethene
7. 1,1,1-Trichloroethane
8. 1,1,2-Trichloroethane
9. Trichloroethene
10. Benzene
11. Toluene
12. Xylenes

3.8.3
Assure that the RF of each compound (except for freons 11, 12 and 113, chloroethane, and vinyl chloride) is within ±15% difference from the initial calibration's average RF. The RF for freons 11, 12 and 113, chloroethane, and vinyl chloride must be within ±25%.

3.9.0 Blank

3.9.1
Analyze field blank(s) to detect any possible interference from ambient air.

3.9.2
Investigate and determine the source(s) and resolve any laboratory contamination problem prior to analyzing any samples if the blank shows a measurable amount (≥1 µg/L) of the target compound(s).

3.10.0 Sample Analysis

3.10.1
Assure that the requirements for initial calibration, daily mid-point check, blank, and LCS are met before any site samples are analyzed.

3.10.2
Analyze samples within 30 minutes after collection to minimize VOC loss. Longer holding time may be allowed if the laboratory uses a special sampling equipment (e.g., sorbent trap, glass bulb) and demonstrates that the holding time can exceed 30 minutes with no decrease in results.

3.10.3
Assure that the concentrations of constituent(s) in a sample do not exceed 50% of the highest concentration in the calibration range. Reanalyze the sample using a smaller volume or dilution if the detected concentration exceed 50% of the highest concentration in the calibration range.

3.10.4
Attain DL of not more than 1 µg/L for all target compounds. If lesser sample volumes or dilutions are used to off-set possible high concentration of constituents in the initial run, use the initial run to calculate the results for constituents that are not affected by the high concentration so that DL of 1 µg/L for these compounds can be achieved.

3.10.5
Quantify sample results using the average RF from the most recent initial calibration.

3.10.6
Add surrogate compounds to all samples. Assure that the surrogate compound concentration is within the initial calibration range. Two to three different surrogate compounds [one aromatic hydrocarbon and two chlorinated compounds (early and middle eluting, except gases)] should be used to cover the different temperature programming range for each GC run.

3.10.7
Calculate the surrogate recovery for each GC run. Surrogate recovery must not exceed ±25% difference from the true concentration of the surrogate, as the sample result would be considered questionable and may be rejected by this Regional Board.

3.11.0 Compound Confirmation

3.11.1
Conduct compound confirmation by GC/MS whenever possible. Use second column confirmation with surrogate for compound confirmation if GC/MS is not used.

3.11.2
Add surrogate compounds to standards and site samples for second column confirmation to monitor the relative retention time (RRT) shift between GC runs. This is required for better compound identification when ELCD, PID, ECD, and FID are used for analysis.

3.11.3
Usually one sample is adequate and quantitation is not required for second column confirmation. Second column confirmation can be done with a different GC. The representative sample can be collected in Tedlar bag and confirmation can be done off site.

3.11.4
Second column confirmation is not necessary if the compounds present have been confirmed from previous soil gas investigations.

3.12.0 Samples with High Concentration

3.12.1
DL may be raised above 1 µg/L for compounds with high results (i.e., the limit as specified in Section 3.10.3) and those closely eluting compounds for which quantitation may be interfered by the high concentrations.

3.12.2
Quantify sample results according to Section 3.10.4 for analytes which are not affected by the high concentration compounds.

3.12.3
If high VOC concentration in an area is known from previous soil gas analysis, Sections 3.12.1 and 3.12.2 are not necessary when analyzing samples from the area in question.

3.12.4
When dilution with ambient air is used for samples with high results, dilute and analyze in duplicate each day at least one sample to verify the dilution procedure. Ambient air should be checked periodically during each day of analysis.

3.13.0 Shortened Analysis Time

3.13.1
Shorten the GC run time under the following conditions only:

1. The exact number and identification of compounds are known from previous soil and soil gas investigations; and

2. The consultant has been given permission by Regional Board staff to analyze only for specific compounds.

3.13.2
Meet the following requirements when shortening GC run-time:

1. Regional Board staff must approved the shortened run time;

2. The compounds must not coelute;

3. Perform initial calibration and daily mid-point calibration check and analyze LCS and samples under the same conditions as the shorter GC run-time;

4. Quantitate using the average RF from the initial calibration utilizing the shorter run-time; and

5. Perform a normal run-time analysis whenever peaks are detected within retention time windows where coelution, as indicated by the calibration chromatograms, is likely.

3.14.0 Last GC Test Run Per Day of Analysis (Record in Table 1)

3.14.1
A LCS as the last GC run of the day is not mandatory, except under conditions in Section 3.14.2. Include the same compounds used in the daily mid-point calibration check analysis, as listed in Section 3.8.2. Attain RF for each compound within ±20% difference from the initial calibration's average RF, except for freons 11, 12, 113, chloroethane, and vinyl chloride which must be within ±30%.

3.14.2
Analyze a LCS at the detection limit concentration instead of the mid-point concentration if all samples from same day of analysis show non-detect (ND) results. The recovery for each compound must be at least 50%. If it is less than 50%, all the ND results of the samples become questionable.

3.15.0 On-site Evaluation Check Sample

3.15.1
Analyze on-site the evaluation check sample as part of the QA/QC procedures when presented with such a check sample by Regional Board staff. Provide preliminary results on-site.

3.15.2
If the results show that the soil gas consultant has problems with the analysis, all the results generated during the same day may be rejected. Correct all problems before any more samples are analyzed.

3.16.0 Site Inspection

3.16.1
Unannounced, on-site inspection by Regional Board staff is routine. Provide upon request hard copies of the complete laboratory data, including raw data for initial calibration, daily mid-point check, LCS and blank results. Failure to allow such inspection or to present these records or field data may result in rejection of all sample results.

3.16.2
The soil gas consultant must understand the instruments, analytical and QA/QC procedures and must be capable of responding to reasonable inquiries.

3.17.0 Recordkeeping in the Mobile Laboratory
Maintain the following records in the mobile laboratory:

1. A hard copy record of calibration standards and LCS with the following information:

   a. Date of receipt
   b. Name of supplier
   c. Lot number
   d. Date of preparation for intermediate standards (dilution from the stock or concentrated solution from supplier)
   e. ID number or other identification data
   f. Name of person who performed the dilution
   g. Volume of concentrated solution taken for dilution
   h. Final volume after dilution
   i. Calculated concentration after dilution

2. A hard copy of each initial calibration for each instrument used for the past few months.

3. The laboratory standard operating procedures.

4.0 Reporting of Soil Gas Sample Results and QA/QC Data (Record in Table 1 and 2)

4.1
Report all sample test results and QA/QC data using the reporting formats in Appendix A. Compounds may be listed by retention time or in alphabetical order. Include in the table of sample results all compounds in the analyte list. Report unidentified or tentatively identified peaks. Submit upon request all data in electronic format and raw data, including the chromatograms. Identify the source(s) of the contaminants detected in the investigation, as indicated by the data.

4.2
Report the following for all calibration standards, LCS and environmental samples:

1. Site name
2. Laboratory name
3. Date of analysis
4. Name of analyst
5. Instrument identification
6. Normal injection volume
7. Injection time
8. Any special analytical conditions/remark

4.3
Provide additional information, as specified, for different types of analyses. Tabulate and present in a clear legible format all information according to the following grouping:

1. Initial calibration

   a. Source of standard (**STD LOT ID NO.**)
   b. Detector for quantitation (**DETECTOR**)
   c. Retention time (**RT**)
   d. Standard mass or concentration (**MASS/CONC**)
   e. Peak area (**AREA**)
   f. Response factor (**RF**)
   g. Average response factor (**RF_{ave}**)
   h. Standard deviation (**SD_{n-1}**) of RF, i.e.,

   $$[\sum_{i=1}^{n} (RF_{ave} - RF_i)^2 / (n - 1)]^{1/2}$$

   n = number of points in initial calibration

   i. Percent relative standard deviation (**% RSD**), i.e., (SD_{n-1} / RF_{ave}) x 100 (%)
   j. Acceptable range of %RSD (**ACC RGE**)

2. Daily calibration check sample

   a. Source of standard
   b. Detector
   c. Retention time (RT)
   d. Standard mass or concentration
   e. Peak area
   f. Response factor (RF)
   g. Percent difference between RF and RF_{ave} from initial calibration (**% DIFF**)
   h. Acceptable range of %DIFF (**ACC RGE**)

3. LCS. Same format as daily calibration

4. Environmental sample

   a. Sample identification
   b. Sampling depth
   c. Purge volume
   d. Vacuum pressure
   e. Sampling time
   f. Injection time
   g. Injection volume
   h. Dilution factor (or concentration factor if trap is used)
   i. Detector for quantitation
   j. Retention time (RT)
   k. Peak area
   l. Concentration in µg/L (**CONC**)
   m. Total number of peaks found by each detector
   n. Unidentified peaks and/or other analytical remarks

5. Surrogate and second column confirmation

   Mark RT and compound name on: a) second column chromatogram of standard and b) second column chromatogram of confirmation sample.

4.4
Discuss the method(s) to be used for data interpolation (contouring). Provide isoconcentration maps for each VOC detected, total chlorinated volatile organics, total aromatic hydrocarbons, and petroleum-based hydrocarbons for each sampling depth, as applicable. Provide cross-section(s) depicting the geology and changes in contaminant concentration with depth, as justified by the data.

5.0 Companion Soil Sampling

5.1
Discuss soil boring locations with Regional Board staff. Locate borings and sampling depths based on all available information including soil gas test results.

5.2
Conduct the soil sampling and analysis per this Regional Board's **Well Investigation Program General Requirements for Subsurface Investigations, Requirements for Subsurface Soil Investigation** and **Laboratory Requirements for Soil and Water Sample Analyses.**

6.0 Soil Vapor Monitoring Well/Vertical Profiling

Install soil vapor monitoring wells for vertical profiling in areas where significant VOC concentrations were identified during the vapor investigation. The objectives of vertical profiling are to: 1) assess the vertical distribution of VOCs in the vapor phase within the unsaturated zone, 2) determine the spatial pattern of vapor phase soil contamination at different depths within the unsaturated zone, 3) identify migration pathways at depth along which VOCs may have migrated from sources, and 4) serve as discrete monitoring points to evaluate the efficiency of a cleanup action. Soil vapor monitoring wells offer the opportunity to resample as many times as necessary to monitor soil vapor changes over time.

Address appropriate items in the following sections when conducting vertical profiling.

6.1
Install nested, cluster, and/or multi-port vapor monitoring wells to obtain discrete multi-depth soil vapor data in the unsaturated zone. Provide a schematic diagram of the well design and a cross-section of the site showing the major lithologic units and zones for vapor monitoring.

6.2
Collect undisturbed soil samples if fine-grained soils are encountered during drilling of the boring for the probes. Due to air-stripping effect, VOC analysis of soil samples is not acceptable if air drilling method is used. Refer to Section 5.2 for sampling and testing requirements.

6.3
Use all available information (e.g., geologic log, organic vapor concentration reading) to select appropriate depths for vapor monitoring. Install probes at depths with elevated vapor readings (headspace) and/or slightly above fine-grained soils which can retard the migration of VOCs. The deepest probe should be installed above the capillary fringe.

6.4
Consider installing nested vapor probes in the annular space of the groundwater monitoring well to serve as a dual-purpose well if both vapor and groundwater monitoring are required. This design saves costs by installing vapor and groundwater monitoring wells in a single borehole.

6.5
Use small-diameter (e.g., ≤¼-inch) continuous tubing attached from the vapor probe to the ground surface to minimize purge volume.

6.6
Design and construct the vapor wells to serve as long-term monitoring points to evaluate the efficiency of a cleanup action and soil vapor changes over time. Protect the tubing from being damaged or clogged by subsurface soil materials especially in deep installations (e.g., place inside a PVC casing) or consider using ½-inch PVC pipe in place of the tubing. If a tubing is used, consider attaching a weight at the probe tip and/or attaching the tubing onto a supporting pipe or rod to ensure that the probe tip remains in-place during installation.

Properly cap the top end of each tubing/pipe (e.g., control valve) and label each tubing/pipe with the correct sampling depth.

6.7
Attach the bottom-end of the tubing to an appropriate vapor probe (e.g., PVC screen, stainless steel wire screen, stainless steel probe, or brass elbow, etc). If a vacuum pump is used for purging and sampling, include a wire screen around the probe to prevent soil particles from blocking the probe's airways. Ensure that the connection between the tubing and the vapor probe is tight to prevent leakage.

6.8
Place the filter pack (e.g., sand or pea gravel) around each vapor probe and isolate each monitoring zone with bentonite seals. Use an appropriate method (e.g., tremie method) to avoid bridging or segregation during placement of the filter packs and bentonite seals.

Extend the filter pack to a sufficient distance above the probe to allow for settling of backfill materials. In general, the filter pack should not exceed 3 feet in thickness. In deep borings, the filter pack should extend about four feet above the probe to allow for settling of backfill materials and to reduce the potential for the bentonite seal settling around the probe.

Consider placing fine sand above the filter pack to prevent the bentonite seal from entering the filter pack. Place a minimum of two feet thick bentonite seal above and below the filter pack. Allow sufficient time (e.g., one-half to one hour) for bentonite seal to properly hydrate before placing filter pack or cement-based sealing materials.

6.9
Prevent infiltration of surface runoff and unauthorized access (e.g., use a locking subsurface utility vault).

6.10
Specify the schedule for sampling the vapor probes. In general, soil vapor monitoring is required a minimum of one and two months after installation. Due to the VOC stripping caused by air drilling methods, conduct soil vapor monitoring at least two and four months following well completion. Regional Board staff may require a different sampling schedule and additional sampling based upon site conditions and test results.

6.11
Specify the procedures to properly decommission vapor wells that are no longer needed. The decommissioning activity should achieve an effective and long-term seal of subsurface geologic materials and prevent cross contamination in the subsurface.

7.0 Soil Gas Consultants

This Regional Board reserves the authority to review any soil gas consultant's work to assure compliance with all applicable statutes, regulations, orders, and guidelines. It is your responsibility to ascertain that the individual directing the field investigation is professionally qualified and conducts the field work in accordance with the Board's guidance for active soil gas investigations.

Acknowledgements

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Regional Water Quality Control Board-Los Angeles Region (CRWQCB-LA) Soil Gas Committee. Special thanks go to the staff of the CRWQCB-LA for reviewing the information contained in this document. In addition, discussions and written comments received from soil gas consultants have greatly improved its content. Former CRWQCB-LA staff Philip Chandler and Samuel Yu assisted in preparing previous versions of this guideline.

Table 1
SOIL GAS INITIAL CALIBRATION

SITE NAME: _____ LAB NAME: _____ DATE: _____

ANALYST: _____ STD LOT ID NO.: _____ INSTRUMENT ID: _____

NORMAL INJECTION VOLUME: _____ INJECTION TIME: _____

COMPOUND	DETECTOR	1st CONC				2nd CONC				3rd CONC				RF_{ave}	SD_{n-1}	%RSD	ACC RGE
		RT/RRT	MASS/CONC	AREA	RF	RT/RRT	MASS/CONC	AREA	RF	RT/RRT	MASS/CONC	AREA	RF				

OR

COMPOUND	DETECTOR	RT/RRT	MASS/CONC	AREA	RF	RF_{ave}	SD_{n-1}	%RSD	ACC RGE
Compound 1		_____	1st conc	_____	_____				
		_____	2nd conc	_____	_____				
		_____	3rd conc	_____	_____				
Compound 2 (Surrogate)									

SOIL GAS DAILY MID-POINT CALIBRATION STANDARD

AND

SOIL GAS LABORATORY CONTROL SAMPLES (LCS)

SITE NAME: _____ LAB NAME: _____ DATE: _____

ANALYST: _____ STD LOT ID NO.: _____ INSTRUMENT ID: _____

NORMAL INJECTION VOLUME: _____ INJECTION TIME: _____

COMPOUND (SURROGATE)	DETECTOR	RT/RRT	MASS/CONC	AREA	RF	%DIFFACC RGE

Table 2
SOIL GAS SAMPLE RESULTS

SITE NAME: _____ LAB NAME: _____ DATE: _____

ANALYST: _____ COLLECTOR: _____ INSTRUMENT ID: _____

NORMAL INJECTION VOLUME: _____

Sample ID	Sample 1	Sample 2	Sample 3 .....
Sampling Depth			
Purge Volume			
Vacuum			
Sampling Time			
Injection Time			
Injection Volume			
Dilution Factor			

COMPOUND	DETECTOR	RT	AREA	CONC	RT	AREA	CONC	RT	AREA	CONC
Compound 1										
Compound 2										
Compound 3										
.										
.										
.										
.										
.										
Surrogate 1										
Surrogate 2										

Total Number of Peaks
by Detector 1 (specify)
by Detector 2 (specify)

Unidentified peaks and/or other analytical remarks

ALTERNATIVE FORMAT FOR REPORTING SOIL GAS SAMPLE RESULTS

SITE NAME: _____ LAB NAME: _____ DATE: _____

Sample ID	Sample 1	Sample 2	Sample 3 ...
Sampling Depth			
COMPOUND CONC	CONC	CONC	
Compound 1			
Compound 2			
Compound 3			
.			
.			
.			
.			
.			
.			

(Page 1 of 2, Results Summary)

SITE NAME: _____ LAB NAME: _____ DATE: _____

ANALYST: _____ COLLECTOR: _____ INSTRUMENT ID: _____

NORMAL INJECTION VOLUME: _____

Sample ID	Sample 1		Sample 2		Sample 3 ...	
Sampling Depth						
Purge Volume						
Vacuum						
Sampling Time						
Injection Time						
Injection Volume						
Dilution Factor						
COMPOUND DETECTOR	RT	AREA	RT	AREA	RT	AREA
Compound 1						
Compound 2						
Compound 3						
.						
.						
.						
Surrogate 1						
Surrogate 2						
.						
.						
Total Number of Peaks						
by Detector 1 (specify)						
by Detector 2 (specify)						

Unidentified peaks and/or other analytical remarks

(Page 2 of 2, Analytical Raw Data)

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January 28, 2003

To: Interested Parties

ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

In a coordinated effort, the Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) have jointly developed the "Advisory – Active Soil Gas Investigations" (see the attached). This document is to ensure that consistent methodologies are applied during active soil gas investigations to produce high quality data for regulatory decision-making. The document has been reviewed by other government organizations and by the soil gas consulting community. Their comments have been considered and, where appropriate, incorporated in the document. This is an on-going effort to streamline the characterization of gas phase contaminant sites. As additional knowledge and experience are obtained, this Advisory may be modified as appropriate.

This document is issued by DTSC and LARWQCB as an Advisory subject to review and revision as necessary. The information in this Advisory should not be considered as regulations. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation.

If you have any questions regarding this document, please contact the joint-agency project coordinator Mr. Joe Hwong, of DTSC, at (714) 484-5406.

Sincerely,

Edwin F. Lowry
Director
Department of Toxic Substances Control

Dennis A. Dickerson
Executive Officer
California Regional Water Quality Control Board
Los Angeles Region

Enclosure

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web-site at www.dtsc.ca.gov.

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ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

As a coordinated effort, this document is issued by the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) and Department of Toxic Substances Control (DTSC) as an Advisory subject to review and revision as necessary. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation. The information in this Advisory should not be considered as regulations. In this Advisory, "Agency" should mean LARWQCB and/or DTSC.

1.0 INTRODUCTION

Active soil gas investigations are useful to obtain vapor phase data at sites potentially affected by volatile organic compounds (VOCs), including chlorinated and aromatic hydrocarbons. Active soil gas investigations may also be used to investigate sites potentially affected by methane and hydrogen sulfide, and to measure fixed and biogenic gasses (e.g., oxygen, carbon dioxide, or carbon monoxide). Among other things, the data can be used to identify the source and determine the spatial distribution of VOC contamination at a site, or to estimate indoor air concentrations for risk assessment purposes.

For site characterization, the Agency encourages both soil gas and soil matrix sampling. Typically, soil gas data are more representative of actual site conditions in coarse-grained soil formations while soil matrix data are more representative of actual site conditions in fine-grained soil formations. For evaluating the risk associated with vapor intrusion to indoor air, soil gas data are the preferred contaminant data set, where practicable. Flux chamber and passive sampling methods are not discussed in this Advisory. Any sites where such sampling methods are necessary will be addressed separately.

On February 25, 1997, LARWQCB re-issued the "Interim Guidance for Active Soil Gas Investigation" (ASGI) as guidance for investigating sites with potential VOC contamination. Unless otherwise noted in this Advisory, the active soil gas investigation should be performed in accordance with the most current ASGI.

2.0 SUPPLEMENTAL RECOMMENDATIONS

The following sections supplement the ASGI in an effort to ensure that consistent methodologies are applied during soil gas investigations to produce reliable and defensible data of high quality. All sampling probe installation, sampling, and analytical procedures, whether or not discussed below, are subject to Agency review and approval.

2.1 Project Management
2.2 Soil Gas Sampling Probe Installation
2.3 Purge Volume Test
2.4 Leak Test
2.5 Purge/Sample Flow Rate
2.6 Soil Gas Sampling
2.7 Analysis of Soil Gas Samples

2.1 Project Management

2.1.1 Workplan: An appropriate workplan should be prepared and submitted to the Agency for review and approval at least 30 days prior to its implementation. Any variations or deviations from this Advisory should be specified in the workplan. The soil gas workplan can either be incorporated as part of a comprehensive site investigation workplan or as a stand-alone document, depending on site-specific circumstances.

2.1.2 Field Activities

A. The Agency should be notified 10 working days prior to implementation of field activities. All necessary permits and utility clearance(s) should be obtained prior to conducting any investigations described in this Advisory.

B. All engineering or geologic work (e.g., logging continuous soil cores, soil description) should be performed or supervised by a California Registered Professional in accordance with the Business and Professions Code, Chapters 7 and 12.5, and the California Code of Regulations, Title 16, Chapters 5 and 29.

In addition, for proposed school sites, all work performed should be under the direction and supervision of a project coordinator experienced in soil gas investigations [e.g., an Environmental Assessor as defined in Education Code Section 17210(b)].

C. Evaluation of raw data by Agency staff may occur either in the field or in the office.

1. Hard copies of the complete raw laboratory data, including handwritten data and field notes, should be provided to the Agency staff upon request.

2. Adjustments or modifications to the sampling program may be required by Agency staff to accommodate changes mandated by evaluation of the data set or unforeseen site conditions.

D. Investigation derived wastes (IDWs) should be managed as hazardous waste until proven otherwise or until specifically approved by the Agency as being non-hazardous waste. IDWs should be handled and disposed in accordance with federal, state and local requirements.

E. Field Variations

1. To expedite the completion of field activities and avoid potential project delays, contingencies should be proposed and included in the project workplan (e.g., soil matrix samples will also be collected if clayey soils [as defined in the Unified Soil Classification System (USCS)] are encountered during the proposed soil gas investigation).

2. The Agency field staff should be informed of any problems, unforeseen site conditions, or deviations from the approved workplan. When it becomes necessary to implement modifications to the approved workplan, the Agency should be notified and a verbal approval should be obtained before implementing changes.

F. Soil Matrix Sampling Requirements: Companion soil matrix sampling may be conducted concurrently with a soil gas investigation (in accordance with the ASGI, Section 5.0), except where extremely coarse-grained soils (as defined in USCS) are encountered or when specifically excluded by the Agency.

2.1.3 Soil Gas Investigation Reports: A soil gas investigation report including a discussion of field operations, deviations from the approved workplan, data inconsistencies, and other significant operational details should be prepared. The report may either be a stand-alone document in a format recommended by the Agency or be included within a site-specific assessment report. At a minimum, the report should contain the following:

A. Site plan map and probe location map at an appropriate scale as specified in the workplan (e.g., scale: one inch = 40 feet);

B. Final soil gas iso-concentration maps for contaminants of concern at the same scale as the site plan map;

C. Summary tables for analytical data, in micrograms per liter (μg/L), in accordance with the ASGI;

D. Legible copies of field and laboratory notes or logs;

E. All analytical results and Quality Assurance/Quality Control (QA/QC) information including tables and explanations of procedures, results, corrective actions and effect on the data, in the format specified by the Agency; and

F. Upon request, all raw data including chromatograms and calibration data should be submitted to the Agency.

2.2 Soil Gas Sampling Probe Installation

2.2.1 Lithology: Site soil or lithologic information should be used to select appropriate locations and depths for soil gas probes. If on-site lithologic information is not available prior to conducting the soil gas investigation, at least one (1) continuously cored boring to the proposed greatest depth of the soil gas investigation should be installed at the first sampling location, unless specifically waived or deferred by Agency. Depending on site conditions, additional continuously cored borings may be necessary.

A. Lithologic logs should be prepared for all borings (e.g., continuously cored borings, soil matrix sampling, geotechnical sampling, etc.). Note: This does not apply to direct-push soil gas probe installations.

B. Information gathered from the continuously cored borings may include soil physical parameters, geotechnical data and contaminant data.

C. If low-flow or no-flow conditions (e.g., fine-grained soil, clay, soil with vacuum readings that exceed approximately 10 inches of mercury or 136 inches of water) are encountered, soil matrix sampling using EPA Method 5035A should be conducted in these specific areas. Also see Section 4 of LARWQCB's "General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites" on use of EPA Method 5035A.

D. If the bottom five (5) feet of a continuously cored boring is composed of clay or soil with a vacuum exceeding approximately 10 inches of mercury or 136 inches of water, the continuously cored boring should be extended an additional five (5) feet to identify permeable zones. If the extended boring is also composed entirely of clay, the boring may be terminated. Special consideration should always be given to advancing borings and ensuring that a contaminant pathway is not being created through a low permeability zone.

2.2.2 Sample Spacing: A scaled site plan depicting potential or known areas of concern (e.g., existing or former sumps, trenches, drains, sewer lines, clarifiers, septic systems, piping, underground storage tanks [USTs], chemical or waste management units) should be provided in the project workplan. Sample spacing should be in accordance with the most current ASGI and may be modified based on site-specific conditions with Agency approval. To optimize detecting and delineating VOCs, the grid spacing should be modified to include biased sampling locations.

2.2.3 Sample Depth: Sample depths should be chosen to minimize the effects of changes in barometric pressure, temperature, or breakthrough of ambient air from the surface; and to ensure that representative samples are collected. Consideration should be given to the types of chemicals of concern and the lithology encountered.

A. At each sample location, soil gas probes should be installed at a minimum of one sample depth, generally at five (5) feet below ground surface (bgs), in accordance with the most current ASGI.

B. Samples should be collected near lithologic interfaces or based on field instrument readings (e.g., Flame Ionization Detector [FID], Photo Ionization Detector [PID]) from soil cuttings and/or cores to determine the location of maximum analyte concentrations at the top or bottom of the interface depending upon the analyte.

C. Multi-depth sampling is appropriate for any of the following locations:

1. Sites identified with subsurface structures (e.g., USTs, sumps, clarifiers, waste or chemical management units), subsurface sources (e.g., oil fields, artificial fill, buried animal waste), changes in lithology, and/or contaminated groundwater. Soil gas probes should be emplaced below the base of any subsurface structures, sources or backfilled materials in the vadose zone. Collection of deeper samples should be done in consultation with Agency staff;

2. Areas with significantly elevated VOC concentrations detected during shallow or previous vapor sampling;

3. Areas where elevated field instrument readings are encountered from soil matrix cuttings, cores or samples; or

4. In the annular space of groundwater monitoring wells during construction, where an assessment of the vertical extent of soil gas contamination is necessary.

D. If no lithologic change or contamination is observed, default sampling depths may be selected for multi-depth sampling. For example, soil gas samples may be collected at 5, 15, 25, 40 feet bgs, etc., until either the groundwater is encountered or VOCs are not detected, whichever comes first.

1. Additional samples may be necessary based on site conditions.

2. For Preliminary Endangerment Assessments: When 40 feet bgs is reached, collection of deeper samples may be waived.

However, assessment and/or characterization of the deeper vadose zone may be required in the future to protect groundwater resources.

2.2.4 Sampling Tubes: Sampling tubes should be of a small diameter (1/8 to 1/4 inch) and made of material (e.g., nylon, polyethylene, copper or stainless steel) which will not react or interact with site contaminants. For example, metal tubes should not be used for collection of hydrogen sulfide samples.

A. Clean, dry tubing should be utilized at all times. If moisture, water, or an unknown material is present in the probe prior to insertion, the tubing should be decontaminated or replaced.

B. After use at each location:

1. Non-reusable (e.g., nylon or polyethylene) sampling tubes should be discarded; or

2. Reusable sampling tubes should be properly decontaminated as specified in Section 2.2.7.

C. A drawing of the proposed probe tip design and construction should be included in the project workplan.

2.2.5 Soil Gas Probe Emplacement Methods

A. Permanent or Semi-permanent Soil Gas Probe Methods: Permanent or semi-permanent soil gas probes may be installed, using a variety of drilling methods. Please note that the mud rotary drilling method is not acceptable for soil gas probe emplacement. Other drilling methods such as air rotary and rotosonic can adversely affect soil gas data during and after drilling and will require extensive equilibration times. Therefore, they are not recommended. Other soil gas probe designs and construction (e.g., soil gas wells or nested wells) may be appropriate and should be discussed with Agency staff prior to emplacement. When additional sampling is not anticipated per consultation with the Agency, such probes may be properly removed or decommissioned after completion of the soil gas investigation.

1. The probe tip should be emplaced midway within a minimum of one (1) foot of sand pack. The sand pack should be appropriately sized (e.g., no smaller than the adjacent formation) and installed to minimize disruption of airflow to the sampling tip. See Figure 1 for more information.

2. At least one (1) foot of dry granular bentonite should be emplaced on top of each sand pack to preclude the infiltration

of hydrated bentonite grout. The borehole should be grouted to the surface with hydrated bentonite. With respect to deep probe construction with multiple probe depths, the borehole should be grouted between probes. One (1) foot of dry granular bentonite should be emplaced between the filter pack and the grout at each probe location. See Figure 2 for more information.

3. The use of a downhole probe support may be required for deep probe construction (e.g., 40 feet bgs for direct push probes).

   a. Such probe support may be constructed from a one-inch diameter bentonite/cement grouted PVC pipe or other solid rod, or equivalent, allowing probes to be positioned at measured intervals.

   b. The support should be properly sealed or solid (internally or externally) to avoid possible cross-contamination or ambient air intrusion.

   c. The probes should be properly attached to the exterior of the support prior to placement downhole.

   d. Alternative probe support designs should be described in the project workplan. If probe support will not be used for deep probes, justification should be included in the project workplan.

4. Tubing should be properly marked at the surface to identify the probe location and depth.

5. As-built diagrams for probes or wells should be submitted with the soil gas investigation report detailing the well identification and corresponding probe depths. A typical probe construction diagram may be submitted for probes with common design and installation.

6. Unless soil gas probes are removed or decommissioned, probes should be properly secured, capped and completed to prevent infiltration of water or ambient air into the subsurface and to prevent accidental damage or vandalism. For surface completions, the following components may be installed:

   a. Gas-tight valve or fitting for capping the sampling tube;

   b. Utility vault or meter box with ventilation holes and lock;

   c. Surface seal; and

   d. Guard posts.

B. Temporary Soil Gas Probe Emplacement Method: In general, the drive rod is driven to a predetermined depth and then pulled back to expose the inlets of the soil gas probe. After sample collection, both the drive rod and tubing are removed.

1. During installation of the probe, hydrated bentonite should be used to seal around the drive rod at ground surface to prevent ambient air intrusion from occurring.

2. The inner soil gas pathway from probe tip to the surface should be continuously sealed (e.g., a sampling tube attached to a screw adapter fitted with an o-ring and connected to the probe tip) to prevent infiltration.

2.2.6 Equilibration Time: During probe emplacement, subsurface conditions are disturbed. To allow for subsurface conditions to equilibrate, the following equilibration times are recommended:

A. For probes installed with the direct push method where the drive rod remains in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 20 minutes following probe installation.

B. For probes installed with the direct push method where the drive rod does not remain in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 30 minutes following probe installation.

C. For probes installed with hollow stem drilling methods, purge volume test, leak test, and soil gas sampling should not be conducted for at least 48 hours (depending on site lithologic or drilling conditions) after the soil gas probe installation.

D. Probe installation time should be recorded in the field log book.

2.2.7 Decontamination: After each use, drive rods and other reusable components should be properly decontaminated to prevent cross contamination. These methods include:

A. 3-stage wash and rinse (e.g., wash equipment with a non-phosphate detergent, rinse with tap water, and finally rinse with distilled water); and/or

B. Steam cleaning process.

2.3 Purge Volume Test

To ensure stagnant or ambient air is removed from the sampling system and to assure samples collected are representative of subsurface conditions, a

purge volume versus contaminant concentration test should be conducted as the first soil gas sampling activity at the selected purge test point. The purge volume test is conducted by collecting and analyzing a sample for target compounds after the removal of appropriate purge volumes.

2.3.1 Purge Test Locations: The purge test location should be selected as near as possible to the anticipated or confirmed contaminant source, and in an area where soil gas concentrations are expected to be greatest based on lithology (e.g., coarse-grained sediments). The first purge test location should be selected through the workplan approval process or as a field decision in conjunction with Agency staff.

2.3.2 Purge Volume: The purge volume or "dead space volume" can be estimated based on a summation of the volume of the sample container (e.g., glass bulbs), internal volume of tubing used, and annular space around the probe tip. Summa™ canisters, syringe, and Tedlar™ bags are not included in the dead space volume calculation. The Agency recommends step purge tests of one (1), three (3), and seven (7) purge volumes be conducted as a means to determine the purge volume to be applied at all sampling points.

A. The appropriate purge volume should be selected based on the highest concentration for the compound(s) of concern detected during the step purge tests. The purge volume should be optimized for the compound(s) of greatest concern in accordance with Section 2.2 of the ASGI.

B. If VOCs are not detected in any of the step purge tests, a default of three (3) purge volumes should be extracted prior to sampling.

C. The step purge tests and purging should be conducted at the same rate soil gas is to be sampled (see Section 2.5).

D. The purge test data (e.g., calculated purge volume, rate and duration of each purge step) should be included in the report to support the purge volume selection.

2.3.3 Additional Purge Volume Test

A. Additional purge volume tests should be performed to ensure appropriate purge volumes are extracted if:

1. Widely variable or different site soils are encountered; or

2. The default purge volume is used and a VOC is newly detected.

B. If a new purge volume is selected after additional step purge tests are conducted, the soil gas investigation should be continued as follows:

1. In areas of the same or similar lithologic conditions:

a. Re-sample 20 percent of the previously completed probes. This re-sampling requirement may be reduced or waived in consultation with Agency staff, depending on site conditions. If re-sampling indicates higher detections (e.g., more than 50 percent difference in samples detected at greater than or equal to 10 μg/L), all other previous probes should be re-sampled using the new purge volume.

b. Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

2. In areas of different lithologic conditions: Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

2.4 Leak Test

Leakage during soil gas sampling may dilute samples with ambient air and produce results that underestimate actual site concentrations or contaminate the sample with external contaminants. Leak tests should be conducted to determine whether leakage is present (e.g., the leak check compound is detected and confirmed in the test sample after its application).

2.4.1 Leak tests should be conducted at every soil gas probe.

2.4.2 Leak Check Compounds: Tracer compounds, such as pentane, isopropanol, isobutene, propane, and butane, may be used as leak check compounds, if a detection limit (DL) of 10 μg/L or less can be achieved. These compounds may be contained in common products such as shaving cream.

2.4.3 A leak check compound should be placed at any location where ambient air could enter the sampling system or where cross contamination may occur, immediately before sampling. Locations of potential ambient air intrusion include:

A. Sample system connections;

B. Surface bentonite seals (e.g., around rods and tubing); or

C. Top of the Temporary Soil Gas Probe (see Section 2.2.5.B).

2.4.4 The leak test should include an analysis of the leak check compound. If a leak check compound is detected in the sample, the following actions should be followed:

A. The cause of the leak should be evaluated, determined and corrected through confirmation sampling;

B. If the leak check compound is suspected or detected as a site-specific contaminant, a new leak check compound should be used;

C. If leakage is confirmed and the problem can not be corrected, the soil gas probe should be properly decommissioned;

D. A replacement probe should be installed at least five (5) feet from the original probe decommissioned due to confirmed leakage, or consult with Agency staff; and

E. The leak check compound concentration detected in the soil gas sample should be included and discussed in the report.

2.5 Purge/Sample Flow Rate

Sampling and purging flow rates should not enhance compound partitioning during soil gas sampling. Samples should not be collected if field conditions as specified in Section 2.6.4 exist.

2.5.1 The purging or sampling flow rate should be attainable in the lithology adjacent to the soil gas probe.

A. To evaluate lithologic conditions adjacent to the soil gas probe (e.g., where no-flow or low-flow conditions), a vacuum gauge or similar device should be used between the soil gas sample tubing and the soil gas extraction devices (e.g., vacuum pump, Summa™ canister).

B. Gas tight syringes may also be used to qualitatively determine if a high vacuum soil condition (e.g., suction is felt while the plunger is being withdrawn) is present.

2.5.2 The Agency recommends purging or sampling at rates between 100 to 200 milliliters per minute (ml/min) to limit stripping, prevent ambient air from diluting the soil gas samples, and to reduce the variability of purging rates. The low flow purge rate increases the likelihood that representative samples may be collected. The purge/sample rate may be modified based on conditions encountered in individual soil gas probes. These modified rates should be documented in the soil gas report.

2.6 Soil Gas Sampling

After the soil gas probe is adequately purged, samples should be collected by appropriate methodologies.

2.6.1 Sample Container: Samples should be collected in gas-tight, opaque/dark containers (e.g., syringes, glass bulbs wrapped in aluminum foil, Summa™ canisters), so that light-sensitive or halogenated VOCs (e.g., vinyl chloride) will not degrade.

A. If a syringe is used, it should be leak-checked before each use by closing the exit valve and attempting to force ambient air through the needle.

B. If syringe samples are analyzed within five (5) minutes of collection, aluminum foil wrapping may not be necessary.

C. EPA Method TO-14A, TO-15, or an equivalent air analysis method, requires samples be collected in Summa™ canisters.

D. If a Summa™ canister is used, a flow regulator should be placed between the probe and the Summa™ canister to ensure the Summa™ canister is filled at the flow rate as specified in Section 2.5.2.

E. Tedlar™ bags should not be used to collect VOC samples.

F. Specific requirements for methane and hydrogen sulfide sample containers are specified in Section 2.7.9.

2.6.2 Sample Collection

A. Vacuum Pump: When a vacuum pump is used, samples should be collected on the intake side of the vacuum pump to prevent potential contamination from the pump. Vacuum readings or qualitative evidence of a vacuum should be recorded on field data sheets for each sample.

B. Shallow Samples: Care needs to be observed when collecting shallow soil gas samples to avoid sample breakthrough from the surface. Extensive purging or use of large volume sample containers (e.g., Summa™ canisters) should be avoided for collection of near-surface samples [e.g., shallower than five (5) feet bgs].

2.6.3 Sample Container Cleanliness and Decontamination

A. Prior to its first use at a site, each sample container should be assured clean by the analytical laboratory as follows:

1. New containers should be determined to be free of contaminants (e.g., lubricants) by either the supplier or the analytical laboratory; and

2. Reused/recycled containers: Method blank(s), as specified in Section 2.7.1.A, should be used to verify sample container cleanliness.

B. After each use, reusable sample containers should be properly decontaminated.

1. Glass syringes or bulbs should be disassembled and baked at 240° C for a minimum of 15 minutes or at 120° C for a minimum of 30 minutes, or be decontaminated by an equivalent method.

2. Summa™ canisters should be properly decontaminated as specified by appropriate EPA analytical methods.

3. During sampling activities using reused/recycled sampling containers (e.g., glass syringes, glass bulbs), at a minimum one (1) decontaminated sample container per 20 samples or per every 12 hours, whichever is more often, should be used as a method blank (as specified in Section 2.7.1.A) to verify and evaluate the effectiveness of decontamination procedures.

C. Plastic syringes should be used only once and then properly discarded.

2.6.4 Field Conditions: Field conditions, such as rainfall, irrigation, fine-grained sediments, or drilling conditions may affect the ability to collect soil gas samples.

A. Wet Conditions: If no-flow or low-flow conditions are caused by wet soils, the soil gas sampling should cease. In addition, the Agency recommends that the soil gas sampling should not be conducted during or immediately after a significant rain event (e.g., 1/2 inch or greater) or onsite watering.

B. If low flow conditions are determined to be from a specific lithology, a new probe should be installed at a greater depth or a new lateral location should be selected after evaluation of the site lithologic logs (See Section 2.2.1) or in consultation with Agency staff.

C. If moisture or unknown material is observed in the glass bulb or syringe, soil gas sampling should cease until the cause of the problem is determined and corrected.

D. If refusal occurs during drilling, soil gas samples should be collected as follows or in consultation with Agency staff.

1. For sample depths less than five feet, collect a soil gas sample following the precautions outlined in Section 2.6.2.B.

2. For sample depths greater than five feet, collect a soil gas sample at the depth of refusal.

3. A replacement probe should be installed within five (5) feet laterally from the original probe decommissioned due to refusal. If refusal still occurs after three tries, the sampling location may be abandoned.

2.6.5 Chain of Custody Records: A chain of custody form should be completed to maintain the custodial integrity of a sample. Probe installation times and sample collection times should be included in the soil gas report.

2.7 Analysis of Soil Gas Samples

2.7.1 Quality Assurance/Quality Control (QA/QC): The soil gas analytical laboratory should comply with the project Quality Assurance Project Plan (QAPP) and follow the QA/QC requirements of the most current ASGI and the employed EPA Method. If there is any inconsistency, the most restrictive and specific requirements should prevail. The analytical data should be consistent with the Data Quality Objectives (DQOs) established for the project. The Agency staff may inspect the field and/or laboratory QA/QC procedures. Copies of the QA/QC plan and laboratory calibration data should be presented to the Agency field staff upon request.

Field QC samples should be collected, stored, transported and analyzed in a manner consistent with site samples. The following QC samples should be collected to support the sampling activity:

A. Sample Blanks

1. Method Blanks: Method blanks should be used to verify the effectiveness of decontamination procedures as specified in Section 2.6.3.B.3 and to detect any possible interference from ambient air.

2. Trip Blanks for Off-site Shipments: Whenever VOC samples are shipped offsite for analysis, a minimum of one (1) trip blank

per day should be collected and analyzed for the target compounds. Trip blanks, consisting of laboratory grade ultra pure air, are prepared to evaluate if the shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected VOC samples. Trip blank containers and media should be the same as site samples.

B. Duplicate Samples: At least one (1) duplicate sample per laboratory per day should be field duplicate(s). Duplicate samples should be collected from areas of concern.

1. Duplicate samples should be collected in separate sample containers, at the same location and depth.

2. Duplicate samples should be collected immediately after the original sample.

C. Laboratory Control Samples and Dilution Procedure Duplicates: Laboratory Control Samples (LCS) and Dilution Procedure Duplicates (DPD) should be done in accordance with the most recent ASGI (Sections 3.5.0 and 3.12.4, respectively).

D. Split Samples: The Agency staff may request that split samples be collected and analyzed by a separate laboratory.

2.7.2 Laboratory Certification: Although the California Department of Health Services, Environmental Laboratory Accreditation Program (ELAP) does not currently require certification for soil gas analytical laboratories, the Agency recommends laboratories utilizing EPA Methods 8260B, 8021B, and 8015B for analyses of soil gas samples obtain ELAP certifications for such EPA analytical methods accordingly. The Agency or DTSC's Hazardous Materials Laboratory (HML) staff may inspect the laboratory.

2.7.3 Detection Limits for Target Compounds: Analytical equipment calibration should be in accordance with the most current ASGI. Consideration and determination of appropriate DLs should be based on the DQOs of the investigation.

A. The DL for leak check compounds should be 10 μg/L or less (see Section 2.4.2). The DL for oxygen (O_2) and carbon dioxide (CO_2) should be one (1) percent or less. The DLs for methane and hydrogen sulfide are specified in Section 2.7.9.

B. If the investigation is being conducted to delineate the extent of contamination, a DL of 1 μg/L is appropriate for all targeted VOCs.

C. If the soil gas data are to be used to support risk assessment activities, a DL of 1 μg/L may be appropriate for the initial screening when evaluating all targeted VOCs. If the data are non-detect for all targeted VOCs, additional sampling with lower DLs is not required. If VOCs are detected, additional sampling, using a DL of 0.1 μg/L, may be required to confirm the non-detection of carcinogenic VOCs [see the Toxicity Criteria Database of the California Environmental Protection Agency, Office of Environmental Health Hazard (OEHHA), or the Integrated Risk Information System (IRIS) Database of the United States Environmental Protection Agency]. A DL of 0.1 μg/L may be proposed and used for all carcinogenic target VOCs from the beginning of the investigation.

D. Based on site-specific DQO needs, lower DLs may be required. Examples of sites requiring site-specifc DQO needs include, but are not limited to, chlorinated solvents sites, former industrial facilities and landfills. Several less common VOCs, not included on the ASGI-targeted compound list, may require lower detection limits [e.g., bis(chloromethyl)ether, DBCP (1,2-dibromo-3-chloropropane), or ethylene dibromide] when they are known or suspected to be present.

E. If the required DLs cannot be achieved by the proposed analytical method, additional sample analysis by a method achieving these DLs [e.g., EPA Method 8260B with selective ion method (SIM), TO-14A, TO-15] may be required. Use of these methods should comply with the QA/QC requirements as specified in Section 2.7.1.

F. For results with a high DL reported (e.g., due to matrix interference or dilution), the laboratory should provide a written explanation. Re-sampling and analyses may be required at the appropriate DL for a specific compound.

2.7.4 Sample Handling: Exposure to light, changes in temperature and pressure will accelerate sample degradation. To protect sample integrity:

A. Soil gas samples should not be chilled;

B. Soil gas samples should not be subjected to changes in ambient pressure. Shipping of sample containers by air should be avoided; and

C. If condensation is observed in the sample container, the sample should be discarded and a new sample should be collected.

2.7.5 Holding Time: All soil gas samples (e.g., samples of VOCs, methane, fixed gases, or biogenic gases), with the exception of hydrogen sulfide samples, should be analyzed within 30 minutes by an on-site mobile laboratory. Hydrogen sulfide samples should be analyzed as specified in Section 2.7.9.B.2. Under the following conditions, holding times may be extended and analyses performed off-site:

A. Soil gas samples collected in glass bulbs with surrogates added within 15 minutes of collection may be analyzed within 4 hours after collection;

B. Soil gas samples collected in Summa™ canisters may be analyzed within 72 hours after collection; and

C. Methane samples may be analyzed as specified in Section 2.7.9.A.2.

2.7.6 Analytical Methods

A. VOC Samples: All VOC samples should be analyzed using only a Gas Chromatograph/Mass Spectrometer (GC/MS) method (e.g., EPA Method 8260B, used for analysis of soil gas samples, EPA Method TO-14A or TO-15, or equivalent), except at well-characterized sites (e.g., VOCs are known to be present and confirmed based on previous GC/MS analyses). A non-GC/MS method (e.g., EPA Method 8021B, used for analysis of soil gas samples) may be used only for routine monitoring of VOC contamination at well-characterized sites.

If during routine monitoring, new VOC(s) were detected by a non-GC/MS method, then at least 10 percent of the samples with each newly identified VOC should be confirmed by a GC/MS method. Thereafter, routine monitoring can resume with the non-GC/MS method, including the new analyte(s).

B. Methane and Hydrogen Sulfide Samples: These gas samples should be analyzed using methods specified in Section 2.7.9.

2.7.7 Auto samplers may be used if:

A. One (1) sample is introduced at a time;

B. The sample vials are gas-tight and never opened after the sample is added;

C. Proper holding times are maintained (see Section 2.7.5); and

D. All samples are secured and under proper custody.

2.7.8 Target Compounds

A. VOCs

1. ASGI-Targeted Compounds: The ASGI (dated February 25, 1997) includes 23 primary and four (4) other target VOCs. All quantifiable results should be reported.

2. Others: The estimated results of all Tentatively Identified Compounds [TICs]) or non-AGSI-targeted compounds detected should be included in the report. If TICs or non-ASGI-targeted compounds are identified, contact the Agency to determine whether additional action is required (e.g., running additional standards to quantify TICs or non-ASGI compounds) and whether the use of these estimated data for risk evaluation is appropriate.

B. Leak Check Compounds: All quantifiable results should be reported as specified in Section 2.4.4.E.

C. Specific Compounds: Based on the site history and conditions, analyses for specific compounds may be required by the Agency staff. Examples include:

1. In areas where USTs or fuel pipelines are identified, soil gas samples should be analyzed for oxygenated compounds [e.g., methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), di-isopropyl ether (DIPE), tertiary amyl methyl ether (TAME), tertiary butyl alcohol (TBA), and ethanol];

2. At oilfield sites where semi-VOCs or Total Petroleum Hydrocarbons (TPHs) are detected in the soil gas samples, fixed and biogenic gas (O_2, CO_2, and CH_4) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument;

3. At petroleum contaminated sites (including oilfields), dairies, wetlands, landfills or other sites where the presence of methane and/or hydrogen sulfide is suspected, soil gas samples should be analyzed for methane and/or hydrogen sulfide;

4. At sites where use of chlorinated solvents with 1,4-dioxane is suspected or known to exist, soil gas samples may be analyzed for 1,4-dioxane with a detection limit of 1 μg/L; or

5. See Section 2.7.9.A.4 below.

2.7.9 Methane and Hydrogen Sulfide Sampling Programs: If the presence of methane and/or hydrogen sulfide is suspected, they should also be included in the analytical plan. After evaluating the initial soil gas data, the Agency may recommend that testing for methane or hydrogen sulfide cease.

A. Methane Sampling Program: Methane samples may be analyzed by a GC using modified EPA Method 8015B, EPA Method TO-3, or ASTM 3416M (EPA 3C), or by an appropriate hand-held instrument (e.g., Land Tech Gas Analyzer GA-90, Gas Emissions Monitor GEM-500, GEM-2000).

1. Detection Limit: The DL for methane analysis should not exceed 500 parts per million by volume (ppmv).

2. Methane Sample Containers: In addition to the gas-tight sample containers previously specified in Section 2.6.1, Tedlar™ bags may be used for collection of methane samples with a holding time of no more than 24 hours.

3. Methane Screening Level: When methane is detected at 1,000 ppmv or more, additional sampling and/or further investigation is recommended to identify the source(s).

4. At sites where methane is investigated and detected at a level of 5,000 ppmv or more, fixed and biogenic gas (O_2, CO_2, and CH_4) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument.

5. To determine that the area is pressurized by migration of gases, pressure readings of each sampling tube system should be recorded in the field logs and reported along with the methane concentration.

6. Special GC Requirements: The GC method requires calibration curves for analytes such as methane since it is not a normal target analyte for such an analytical method.

7. Special Hand-Held Instruments Requirements: Hand-held instruments should be calibrated in accordance with the manufacture's instructions. When a hand-held instrument is used to analyze methane samples, the Agency recommends that at least 10 percent of all positive methane samples (e.g., more than 5,000 ppmv), rounded to the nearest whole number, be confirmed by another hand-held instrument (different unit or brand) or by a GC method.

B. Hydrogen Sulfide Sampling Program: Hydrogen sulfide may be analyzed by a GC using the South Coast Air Quality Management District (SCAQMD) Method 307-91 or EPA Method 16, or by an

appropriate hand-held instrument (e.g., LTX-310 calibrated for hydrogen sulfide or Jerome 631-X).

1. Detection Limit: The DL should be equal to or less than 0.5 ppmv or be sensitive enough to allow for a modeled ambient air concentration (at least one microgram per cubic meter) at the soil surface.

2. Holding Time: Hydrogen sulfide samples should be extracted directly into a hand-held analyzer within 30 minutes of collection to minimize the risk of losing the hydrogen sulfide due to reaction with active surfaces. If a hand-held instrument is not used, hydrogen sulfide samples should be analyzed as below:

   a. Within 30 minutes of collection, using the GC procedures; or

   b. Within 24 hours of collection, if a surrogate is added to the samples, or 100 percent duplicate samples are collected.

3. Sample Containers: The following sample containers are recommended:

   a. Minimum one (1) liter black Tedlar™ bag fitted with polypropylene valves or the equivalent;

   b. 100-ml gas-tight syringe fitted with an inert valve and wrapped in aluminum foil;

   c. Gas-tight glass bulb wrapped in aluminum foil; or

   d. Glass-lined or silicon coated Summa™ canister.

4. Precautions

   a. Since hydrogen sulfide is extremely unstable in the presence of oxygen and moisture, contact of hydrogen sulfide samples with them should be avoided.

   b. Due to the high reactivity of hydrogen sulfide gas, contact of hydrogen sulfide samples with metallic or other non-passive surfaces should be avoided during sample collection, storage and analysis.

   c. Care must be taken so that GC components do not react with the sample. Typically glass-lined injection ports and Teflon™ tube packed columns are used to avoid loss of hydrogen sulfide due to reaction with active surfaces.

3.0 SOIL PARAMETERS

If the soil gas data will be used in a health risk assessment, an estimation of the indoor air concentration should be performed using soil gas data with an Agency approved or modified predictable indoor air model. Default values of input parameters may be used in accordance with the approved indoor air modeling guidance and in consultation with Agency staff. If default values are not used, site-specific soil parameters should be obtained as discussed below.

To assess health risk, indoor air quality, the threat of groundwater contamination from VOCs, or to evaluate the effectiveness of a proposed remedial technology, the following soil matrix parameters should be obtained from a minimum of three (3) sample locations (at depths* corresponding to or associated with the detected VOCs) for each soil type in association with the soil gas investigation:

3.1 Soil description performed and presented in accordance with the Unified Soil Classification System (USCS);

3.2 Density;

3.3 Organic carbon content of the soil** (by the Walkee Black Method);

3.4 Soil moisture;

3.5 Effective permeability***;

3.6 Porosity; and

3.7 Grain size distribution analysis (curve) and evaluation of fine-grained soil content (by wet sieve analysis and any supplementary methods as necessary) to determine the percent clay, silt and sand. (The grain size distribution analysis will be used to classify the soil in accordance with the U. S. Soil Conservation Service [SCS] soil type, which is the same as the U. S. Department of Agriculture soil type.)

* Samples may be collected from proposed depths at the continuously cored boring.

** This input parameter is required for soil matrix VOC samples only. This parameter sample should not be collected from an impacted area.

*** As an alternative, the measurements of saturated hydraulic conductivity may be used to estimate vapor permeability.

4.0 REFERENCES

Additional information may be found in the following documents:

American Society for Testing and Materials (ASTM), "Standard Guide for Soil Gas Monitoring in the Vadose Zone, ASTM Standard D 5314-92," January 1993; Reapproved 2001; website http://www.astm.org

California Regional Water Quality Control Board, Los Angeles Region, "Interim Guidance for Active Soil Gas Investigation," February 25, 1997

California Regional Water Quality Control Board, Los Angeles Region, "General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites," June 22, 2000

U.S. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition," November 1986, as amended by Updates I (Jul. 1992), II (Sep. 1994), IIA (August 1993), IIB (Jan. 1995), III (Dec. 1996), IIIA (Apr. 1998), IVA (Jan. 1998) and IVB (Nov. 2000); website http://www.epa.gov/SW-846/main.html

U.S. Environmental Protection Agency, "U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-94/012," February 1994; website http://www.epa.gov/region09/qa/superfundclp.html

U.S. Environmental Protection Agency, "Soil Gas Sampling, SOP#: 2042, Revision #: 0.0," June 1, 1996; website http://www.ert.org/respns_resrcs/sops.asp

U.S. Environmental Protection Agency, "Summa Canister Cleaning Procedures, SOP #1703, Rev. #: 0.0," 09/01/94; website http://www.ert.org/respns_resrcs/sops.asp

California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard (OEHHA), Toxicity Criteria Database; website http://www.oehha.ca.gov/risk/ChemicalDB/index.asp

United States Environmental Protection Agency, Integrated Risk Information System (IRIS) Database; website http://www.epa.gov/iris/

ACKNOWLEDGEMENTS

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FOR MORE INFORMATION

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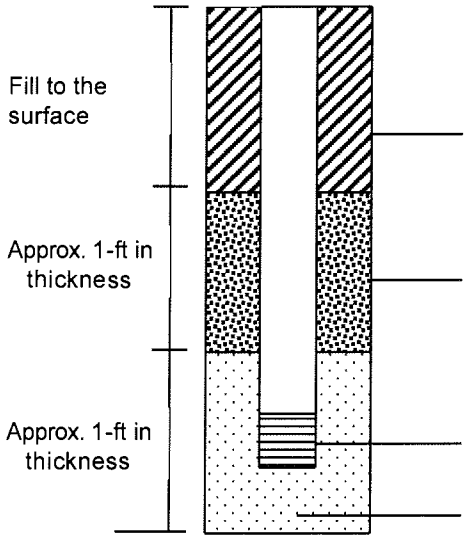
Cypress, California 90630
(714) 484-5406
jhwong@dtsc.ca.gov

Figures – Soil Gas Probe Emplacement Methods

Figure 1 – Permanent/Semi-permanent Gas Probe Construction Diagram



Temporary Gas Probe Method

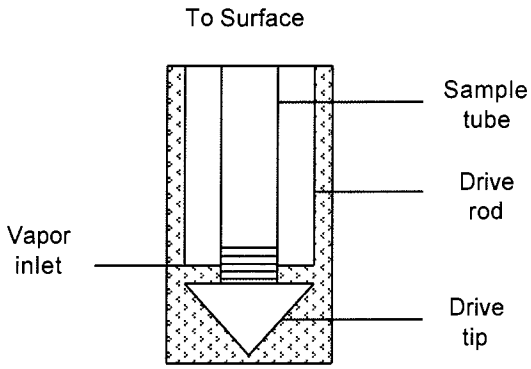
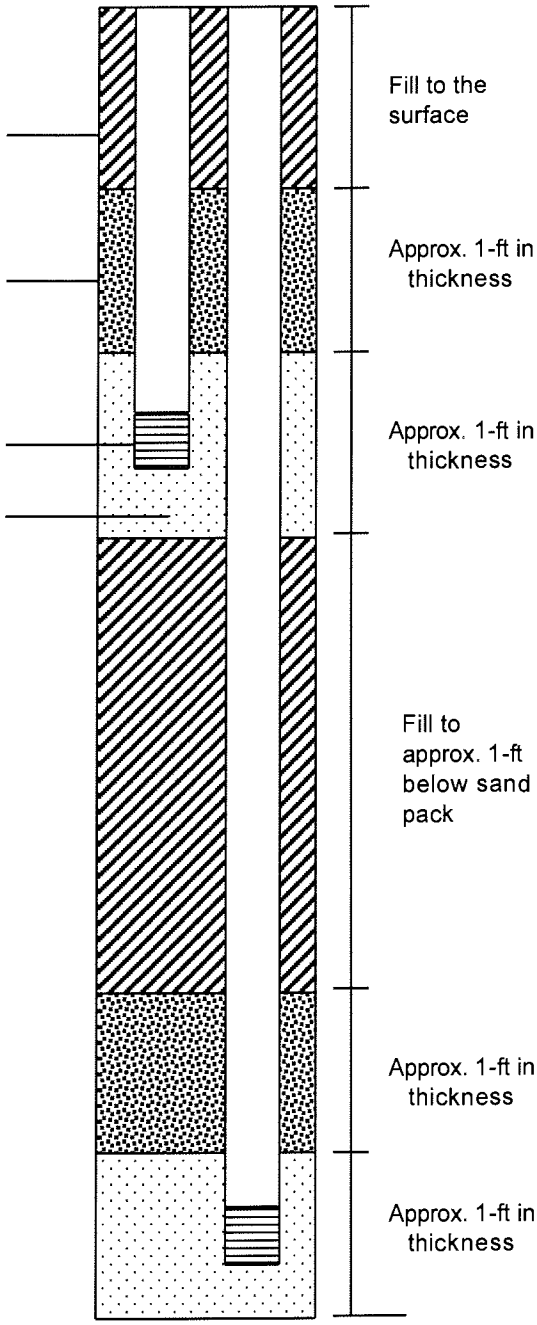


Figure 2 – Multi-depth Gas Probe Construction Diagram



Appendix C
Equipment Lists

Equipment Checklist
Aquifer Test
OU3 Study Area
Phoenix, Arizona

*Field Work Performed By:*_____
*Checklist Verified By:*_____
*Date:*_____

Aquifer Test Equipment

- ☐ Data loggers and associated equipment
- ☐ Soft Silicon Tubing
- ☐ YSI Meter
- ☐ Turbidity Meter
- ☐ Spare disposable bailers
- ☐ Zip Ties
- ☐ Water Level Meter
- ☐ Flow-Through Cell Water Quality Meter
- ☐ Electrical tape - various colors
- ☐ Lap top and cables
- ☐ Interface probe
- ☐ Total depth gauging tape
- ☐ 3/8" Polyethylene Tubing
- ☐ 1/2" Polyethylene Tubing

Decontamination Equipment

- ☐ Spray bottles
- ☐ Alconox/Liquinox
- ☐ Brushes
- ☐ Paper towels
- ☐ Buckets - 3 at minimum
- ☐ Lab water - extra pure
- ☐ ASTM Water
- ☐ DI Water

Miscellaneous

- ☐ Batteries (AA, AAA, C, 9-Volt)
- ☐ Locks (Masterlock 2002)
- ☐ Trash Bags/visqueen
- ☐ Key for Well Locks (Masterlock 2002)
- ☐ Cell Phone W/ Automobile Adapter
- ☐ Business cards
- ☐ Flashing Amber Light
- ☐ Digital/Disposable Camera
- ☐ Duct Tape
- ☐ Silicon Spray (Lubricant)
- ☐ Fishing Kit
- ☐ Vehicle Placards
- ☐ Permits for waste discharge, traffic control

PPE

- ☐ Nitrile Gloves
- ☐ Ear Plugs
- ☐ Safety Vest
- ☐ Work Boots
- ☐ Hard hat
- ☐ Caution Tape

Subcontractors

- ☐ Security guard (if needed)
- ☐ Portable light bank
- ☐ Development rig
- ☐ Pumps and hoses
- ☐ Traffic Control

Tools

- ☐ Toolbox, including:
  - ☐ Allen Wrenches
  - ☐ Allen Keys
  - ☐ Socket Set
  - ☐ Flathead and Phillips Screwdrivers
  - ☐ Replacement Bolts (assort.)
  - ☐ Safety blade
  - ☐ Master Locks (2002)
  - ☐ Tap & Thread Set
  - ☐ Hammer
  - ☐ Vice Grips
  - ☐ Hose Clamps
  - ☐ Polyethylene Clippers
  - ☐ Wire Brush
  - ☐ Pry Bar
  - ☐ Screwdrivers (assort.)

Documentation

- ☐ Pens/Pencils/Sharpies
- ☐ Calculator
- ☐ Stopwatch
- ☐ Chain-of-Custodies

Field Notebook

- ☐ ERM Chain-of-Custodies
- ☐ ERM Pre-Field Memo
- ☐ Site Figures
- ☐ Health & Safety Forms
- ☐ Health & Safety Plan
- ☐ Calibration Form
- ☐ Daily Log
- ☐ Purge Forms
- ☐ Traffic Control Permit
- ☐ Insurance Card
- ☐ Gauging Forms
- ☐ Phone List
- ☐ Vehicle Insurance and Registration Forms

HASP Equipment

- ☐ Eyewash Kit
- ☐ First Aid Kit
- ☐ Fire Extinguisher
- ☐ Traffic Control Cones

Equipment Checklist
Groundwater Sampling
OU3 Study Area
Phoenix, Arizona

*Field Work Performed By:*_____
*Checklist Verified By:*_____
*Date:*_____

Purging Equipment

- ☐ 1/4th-Inch Polyethylene Tubing (Grainger, item #4HM14)
- ☐ Soft Silicon Tubing
- ☐ YSI Meter
- ☐ Turbidity Meter
- ☐ Spare disposable bailers
- ☐ Zip Ties
- ☐ Water Level Meter
- ☐ Flow-Through Cell Water Quality Meter
- ☐ Twine for bailers
- ☐ Measuring Cup
- ☐ Interface probe
- ☐ Total depth gauging tape
- ☐ 3/8" Polyethylene Tubing
- ☐ 1/2" Polyethylene Tubing

Subcontractors

- ☐ Well Development Rig
- ☐ Portable water tank (250 gallons or more)
- ☐ Submersiable pump and pipe
- ☐ Trafic control

Decontamination Equipment

- ☐ Spray bottles
- ☐ Alconox/Liquinox
- ☐ Brushes
- ☐ Paper towels
- ☐ Buckets - 3 at minimum
- ☐ Lab water - extra pure
- ☐ ASTM Water
- ☐ DI Water

Miscellaneous

- ☐ Batteries (AA, AAA, C, 9-Volt)
- ☐ Locks (Masterlock 2002)
- ☐ Trash Bags/visqueen
- ☐ Key for Well Locks (Masterlock 2002)
- ☐ Cell Phone W/ Automobile Adapter
- ☐ Business cards
- ☐ Flashing Amber Light
- ☐ Funnels (Large)
- ☐ Digital/Disposable Camera
- ☐ Duct Tape
- ☐ Silicon Spray (Lubricant)
- ☐ Fishing Kit
- ☐ Packing Tape
- ☐ Vehicle Placards
- ☐ Permits for street closure and sewer discharge

PPE

- ☐ Nitrile Gloves
- ☐ Ear Plugs
- ☐ Safety Vest
- ☐ Work Boots
- ☐ Hard hat

Tools

- ☐ Toolbox, including:
  - ☐ Allen Wrenches
  - ☐ Allen Keys
  - ☐ Socket Set
  - ☐ Flathead and Phillips Screwdrivers
  - ☐ Replacement Bolts (assort.)
  - ☐ Safety blade
  - ☐ Master Locks (2002)
  - ☐ Tap & Thread Set
  - ☐ Hammer
  - ☐ Vice Grips
  - ☐ Hose Clamps
  - ☐ Polyethylene Clippers
  - ☐ Wire Brush
  - ☐ Pry Bar
  - ☐ Screwdrivers (assort.)

Sample Collection

- ☐ 40mL -Volatile Organic Analyte (VOA) bottles
- ☐ 1-liter - Amber bottles
- ☐ Quart bottles for Boron Sampling
- ☐ Sample Labels
- ☐ Plastic Resealable Bags (Gallon and Quart)
- ☐ Ice
- ☐ Sample Coolers
- ☐ Custody Seals
- ☐ Tap Water
- ☐ Bubble Wrap
- ☐ 2" Disposable Bailers
- ☐ Reel and Twine

Documentation

- ☐ Pens/Pencils/Sharpies
- ☐ Calculator
- ☐ Stopwatch
- ☐ Chain-of-Custodies

Field Notebook

- ☐ ERM Chain-of-Custodies
- ☐ ERM Pre-Field Memo
- ☐ Site Figures
- ☐ Health & Safety Forms
- ☐ Health & Safety Plan
- ☐ Calibration Form
- ☐ Daily Log
- ☐ Purge Forms
- ☐ Traffic Control Permit
- ☐ Insurance Card
- ☐ Gauging Forms
- ☐ Phone List
- ☐ Vehicle Insurance and Registration Forms

HASP Equipment

- ☐ Eyewash Kit
- ☐ First Aid Kit
- ☐ Fire Extinguisher
- ☐ Traffic Control Cones

Equipment Checklist
Soil Vapor Sampling
OU3 Study Area
Phoenix, Arizona

*Field Work Performed By:*_____
*Checklist Verified By:*_____
*Date:*_____

Soil Vapor Sampling Equipment

- ☐ Summa Canisters/other sample containers
- ☐ PID meter
- ☐ Flow meter
- ☐ Pressure meter
- ☐ Sample spliter (if needed)
- ☐ Spare disposable tubing
- ☐ Labels
- ☐ Cooler(s)
- ☐ Total depth gauging tape (if needed)
- ☐ Pump
- ☐ T-valve

Decontamination Equipment

- ☐ Spray bottles
- ☐ Alconox/Liquinox
- ☐ Brushes
- ☐ Paper towels
- ☐ Buckets - 3 at minimum
- ☐ Lab water - extra pure
- ☐ ASTM Water
- ☐ DI Water

Miscellaneous

- ☐ Batteries (AA, AAA, C, 9-Volt)
- ☐ Locks (Masterlock 2002)
- ☐ Trash Bags/visqueen
- ☐ Key for Well Locks (Masterlock 2002)
- ☐ Cell Phone W/ Automobile Adapter
- ☐ Business cards
- ☐ Flashing Amber Light
- ☐ Digital/Disposable Camera
- ☐ Duct Tape
- ☐ Silicon Spray (Lubricant)
- ☐ Fishing Kit
- ☐ Vehicle Placards

PPE

- ☐ Nitrile Gloves
- ☐ Ear Plugs
- ☐ Safety Vest
- ☐ Work Boots
- ☐ Hard hat
- ☐ Caution Tape

- ☐ Security guard (if needed)
- ☐ Portable light bank

Tools

- ☐ Toolbox, including:
  - ☐ Allen Wrenches
  - ☐ Allen Keys
  - ☐ Socket Set
  - ☐ Flathead and Phillips Screwdrivers
  - ☐ Replacement Bolts (assort.)
  - ☐ Safety blade
  - ☐ Master Locks (2002)
  - ☐ Tap & Thread Set
  - ☐ Hammer
  - ☐ Vice Grips
  - ☐ Hose Clamps
  - ☐ Polyethylene Clippers
  - ☐ Wire Brush
  - ☐ Pry Bar
  - ☐ Screwdrivers (assort.)

Documentation

- ☐ Pens/Pencils/Sharpies
- ☐ Calculator
- ☐ Stopwatch
- ☐ Chain-of-Custodies

Field Notebook

- ☐ ERM Chain-of-Custodies
- ☐ ERM Pre-Field Memo
- ☐ Site Figures
- ☐ Health & Safety Forms
- ☐ Health & Safety Plan
- ☐ Calibration Form
- ☐ Daily Log
- ☐ Purge Forms
- ☐ Traffic Control Permit
- ☐ Insurance Card
- ☐ Gauging Forms
- ☐ Phone List
- ☐ Vehicle Insurance and Registration Forms

HASP Equipment

- ☐ Eyewash Kit
- ☐ First Aid Kit
- ☐ Fire Extinguisher
- ☐ Traffic Control Cones

Equipment Checklist
Soil Sampling/Well installation
OU3 Study Area
Phoenix, Arizona

*Field Work Performed By:*_____
*Checklist Verified By:*_____
*Date:*_____

Soil Sampling Equipment

- ☐ Zip lock bags
- ☐ PID meter
- ☐ Glass jars w/ lids
- ☐ Alluminum foil
- ☐ Silicon tape
- ☐ Zip Ties
- ☐ Bulk soil sample bags with lables
- ☐ Rock hammer
- ☐ Electrical tape - various colors
- ☐ Cooler(s)
- ☐ Total depth gauging tape (if needed)
- ☐ Water Level Meter (if needed)
- ☐ Interface Probe (if needed)

Decontamination Equipment

- ☐ Spray bottles
- ☐ Alconox/Liquinox
- ☐ Brushes
- ☐ Paper towels
- ☐ Buckets - 3 at minimum
- ☐ Lab water - extra pure
- ☐ ASTM Water
- ☐ DI Water

Miscellaneous

- ☐ Batteries (AA, AAA, C, 9-Volt)
- ☐ Locks (Masterlock 2002)
- ☐ Trash Bags/visqueen
- ☐ Key for Well Locks (Masterlock 2002)
- ☐ Cell Phone W/ Automobile Adapter
- ☐ Business cards
- ☐ Flashing Amber Light
- ☐ Digital/Disposable Camera
- ☐ Duct Tape
- ☐ Silicon Spray (Lubricant)
- ☐ Fishing Kit
- ☐ Vehicle Placards
- ☐ Permits for traffic closure, sewer discharge

PPE

- ☐ Nitrile Gloves
- ☐ Ear Plugs
- ☐ Safety Vest
- ☐ Work Boots
- ☐ Hard hat
- ☐ Caution Tape

Subcontractors

- ☐ Security guard (if needed)
- ☐ Portable light bank
- ☐ Drill rig
- ☐ 55-gallon drum or other approved waste container
- ☐ Portable water tank (250 gallon minimum)
- ☐ Traffic Control

Tools

- ☐ Toolbox, including:
  - ☐ Allen Wrenches
  - ☐ Allen Keys
  - ☐ Socket Set
  - ☐ Flathead and Phillips Screwdrivers
  - ☐ Replacement Bolts (assort.)
  - ☐ Safety blade
  - ☐ Master Locks (2002)
  - ☐ Tap & Thread Set
  - ☐ Hammer
  - ☐ Vice Grips
  - ☐ Hose Clamps
  - ☐ Polyethylene Clippers
  - ☐ Wire Brush
  - ☐ Pry Bar
  - ☐ Screwdrivers (assort.)

Documentation

- ☐ Pens/Pencils/Sharpies
- ☐ Calculator
- ☐ Stopwatch
- ☐ Chain-of-Custodies

Field Notebook

- ☐ ERM Chain-of-Custodies
- ☐ ERM Pre-Field Memo
- ☐ Site Figures
- ☐ Health & Safety Forms
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- ☐ Purge Forms
- ☐ Traffic Control Permit
- ☐ Insurance Card
- ☐ Gauging Forms
- ☐ Phone List
- ☐ Vehicle Insurance and Registration Forms

HASP Equipment

- ☐ Eyewash Kit
- ☐ First Aid Kit
- ☐ Fire Extinguisher
- ☐ Traffic Control Cones

Appendix D
Boart Longyear Standard Groundwater Sampling Procedure

Groundwater Sampling Procedure

Boart Longyear Company
Environmental Drilling Division

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And Water Sampling System 1
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Groundwater Sampling In
Sonic Boreholes 2
What Is Sonic Drilling? 4
Controlled Well Installations/Reduced
Development Time 5

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Boart Longyear Borehole Pumping And Water Sampling System

This technical procedure defines the collection of screening water samples through a 1.5 m (5 ft) long x 5.1 cm (2 in) I.D. stainless steel screen that allows for the development of a real time vertical contaminant profile while drilling a monitoring well borehole. This method also defines the collection of continuous soil samples as an option in conjunction with the water sampling. These two methods aid in accurate placement of well screens to meet every project objectives.

Our technical procedure should be used as a reference for the minimum requirements to provide a consistent quality of field screening results and as guidance for maximizing the potential applications of this system.

Definitions

1. **Rotasonic Technology:**
   A drilling technique that employs simultaneous high-frequency vibration (50 to 150 cycles per second) and low-speed rotational motion coupled with down-pressure to advance the cutting edge of a circular drill string.

2. **Purging:**
   Activity in which water below the inflated packer and within the interval of the stainless steel sampling screen is removed to allow replacement by representative formation water for sampling.

3. **Packer:**
   A compressible cylinder of rubber and metal that is placed inside the drill casing just above the lead rod and screen interval then inflated to seal off the upper casing column during groundwater purging and sampling in the screen interval below the packer.

4. **K-Packer:**
   12.3 cm (4-17/20 in) diameter rubber seal attached to the top of the lead rod to prevent sand from entering the bottom of the sonic casing.

5. **Stainless Steel Screen:**
   A 1.5 m (5 ft) long 5.1 cm (2 in) I.D. stainless steel screen with machined slots over the entire surface area. The bottom of the screen is fitted with a 1.5 m (5 ft) long drive point.

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Groundwater Sampling In Sonic Boreholes

The collection of isolated groundwater samples from a sonic cased borehole with a well screen allows for the vertical delineation of groundwater characteristics through discrete sample collection during drilling in granular materials. When combined with an on-site laboratory program, this method can be an invaluable tool for field programs by providing real-time data for assessing the nature and distribution of dissolved-phase groundwater contamination in three dimensions.

In some cases, vertical chemical profiling and limited permeability data collected through sonic sampling and cased boring can eliminate the time and cost to install and sample multiple-well clusters. The outer sonic casing can be telescoped in order to place multiple well settings in the same borehole. When combined with a field chemistry program, collecting groundwater samples using the isolated water sampling method can eliminate the guesswork involved in the depth-interval placement of the monitoring well screen based on soil headspace readings or other qualitative criteria.

The isolated stainless steel screen method allows for collection of groundwater samples and continuous core samples (if desired) as the boring is advanced using a 10.2 cm (4 in) or 15.2 cm (6 in) I.D. core barrel and this without the use of any circulating medium, such as water, air or mud to collect core samples. The core barrel is advanced 3.0 m (10 ft) at a time followed by the outer sonic casing using some water for lubrication and to prevent possible heaving conditions. The amount of water added for each interval is monitored. The inner barrel would then be pulled and the soil sample extracted and placed in 1.5 m (5 ft) long plastic sleeves. The stainless steel screen is then set at the bottom of the borehole with the lead rod and K-packer. The outer casing is then vibrated back 1.5 m (5 ft) exposing the screen to the formation. The submersible pump and inflatable packer is installed and the volume of water is purged from the isolated zone. The volume of water added during advancement of the drill casing plus 5 volumes of the isolated sampling zone is removed and the water sample is collected. Upon reaching the water table, and at 3.0 m (10 ft) intervals thereafter, water and soil samples are collected for measurement of field parameters, PID headspace, field GC screening, and potentially for off-site laboratory analysis. Upon reaching a final depth, the field analytical data are evaluated as well as the sonic samples (if collected) to determine the placement of well screen interval(s) followed by the installation of the monitoring well(s) as the sonic casing is retracted from the borehole.

Groundwater samples are collected through a pump system that has an inflatable packer located above the pump to effectively seal off the upper casing. The pump is lowered to the top of the lead rod that is attached to the top of the screen and the packer is inflated. The lead rod is approximately 1.5 m (5 ft) long by 8.9 cm (3.5 in) in diameter. The purpose of the lead rod is to keep the screen from becoming lost in the sand when the casing is pulled back. The entire sampling device is retrieved by a wire line and overshot coupler. The K-packer is attached to the upper end of the lead rod and prevents the sand from coming in between the screen and drill casing. The interval below the inflatable packer is developed and purged, and a fresh sample of groundwater is collected.

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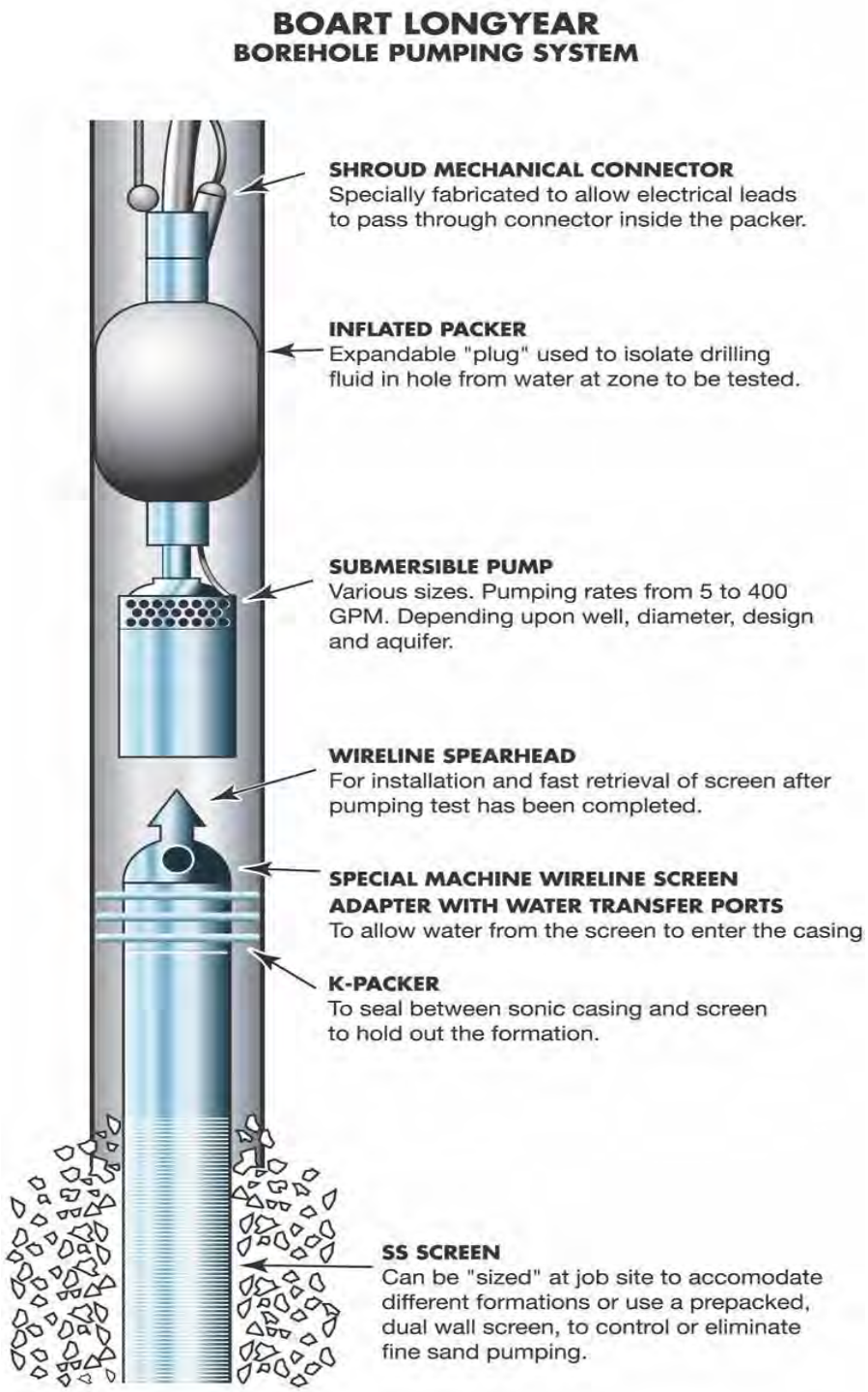
Borehole Pumping System



What Is Sonic Drilling?

Sonic drilling employs simultaneous high-frequency vibrational and low-speed rotation motion coupled with down-pressure to advance a flush thread circular drill pipe.

The sonic method uses a dual line threaded drill pipe, with the inner line being advanced with a core barrel attached to it. Drilling fluid is not used during sampling. This “dry” sampling technique results in the ability to obtain intact core samples, unaltered by drilling fluids. Following the advancement of the inner drill pipe and core barrel, the outer drill casing is advanced to within one foot of the leading edge of the core barrel. The outer casing serves the same purpose as for conventional dual line drilling systems by holding the borehole open for well installation, geophysical logging, or other downhole activities. Drilling fluid maybe introduced during the advancement of the outer drill casing depending on drilling formations.

The procedure for sampling and drilling with the sonic rig involves three steps, which constitute a complete “trip or run”:

1. Advancement of the inner drill string, which includes the core barrel, to a depth determined by the length of the scheduled sampling interval or, the length of the core barrel. Drilling fluid is not added during sampling.
2. Advancement of the outer drill casing over the inner drill string to within 30.5 cm (12 in) of the leading edge of the core barrel. Potable water is sometime used while advancing the outer drill casing.
3. Removal of the inner drill string and extraction of the core sample into a plastic sleeve for field and/or laboratory analysis.

These three steps are repeated until the total depth of the borehole is reached. Rotation and vibration are imparted to both the inner drill string and outer drill casing during sampling and drilling. Extrusion of the sample is induced by vibrating the core barrel and occasionally placing a head of water on top of the core to overcome the adhesion of the sample to the inside of the core barrel. The core sample can be taken directly from the core barrel by extruding it into a plastic sleeve, stainless steel tray or other suitable receptor. Also, for less core disturbance samples can be collected within clear plastic or stainless steel split liners, which are placed inside the core barrel.

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Controlled Well Installations/Reduced Development Time

The outer casing also allows for very controlled placement of wells or any other type of downhole instrumentation. Monitoring wells are installed through the center of the outer drill casing. The construction materials such as the filter pack, bentonite seal and bentonite grout are introduced into the annular space between the outer casing and the well pipe, which can also accommodate a 2.5 to 5.1 cm (1 to 2 in) tremie pipe. After installing the well screen, riser and well construction materials, or instrumentation, the outer casing is gently vibrated back out of the borehole, eliminating any bridging of materials. The vibration positively places the well construction material against the borehole wall around the screen and riser. For these reasons and because the sonic drill system does not tend to smear formations, drills dry or with potable water only, well development times are greatly reduced and well efficiency enhanced when compared to conventional drilling methods.

The inner drill rods and core barrel are equipped with right hand threads and are rotated in a clockwise direction. The outer casing is equipped with left hand threads and is rotated in a counter clockwise direction during advancement. This prevents the unscrewing of the inner drill rods and core barrel as the outer casing is advanced.

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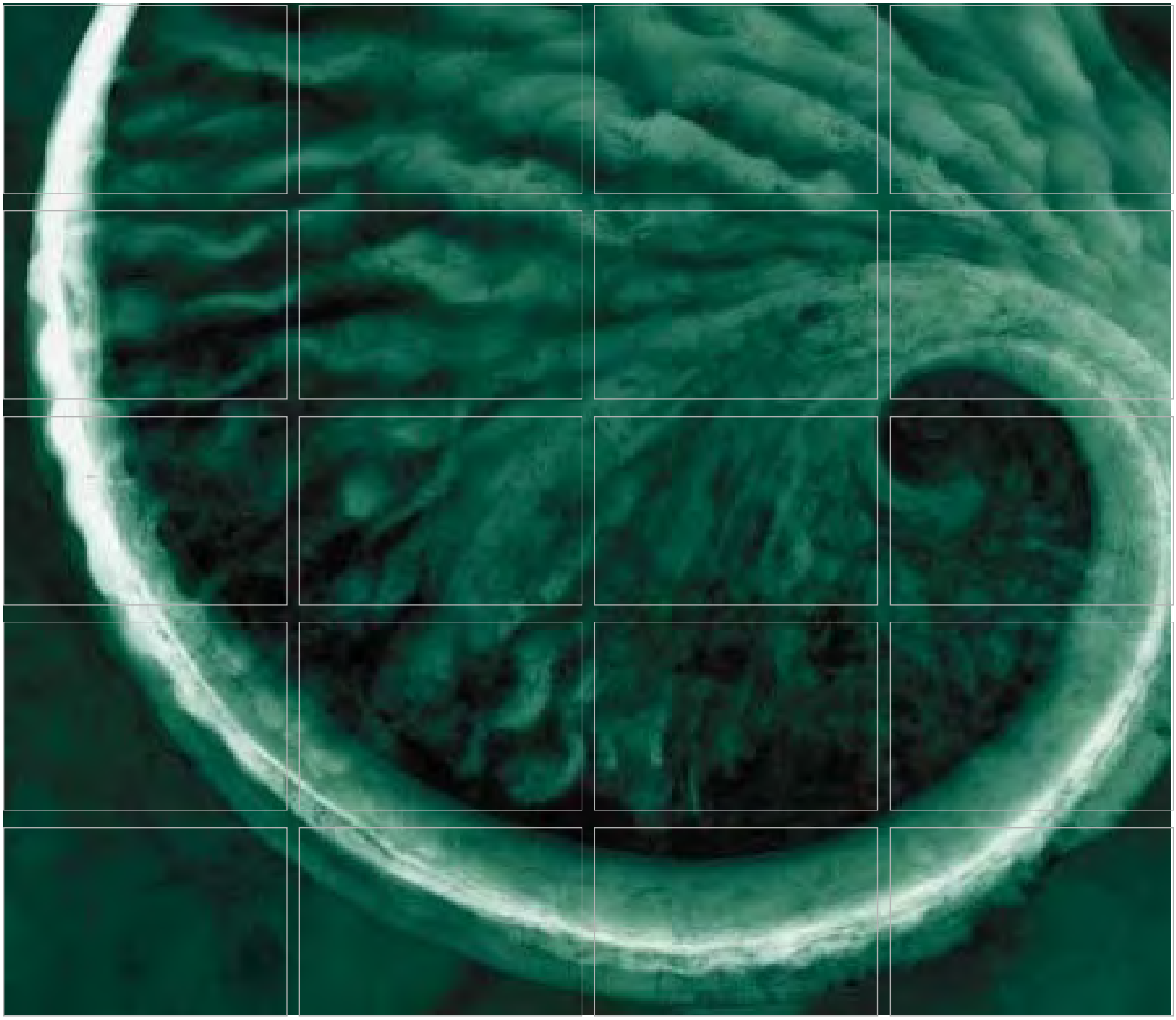
Appendix B
Quality Assurance Project Plan



Final Quality Assurance Project Plan Phase III Remedial Investigation and Feasibility Study

52nd Street Superfund Site Operable Unit 3 Study Area
Phoenix, Arizona

August 2010

Prepared for:
Motorola 52nd Street
Superfund Site
Operable Unit 3
Working Group

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Operable Unit 3
Working Group

Final Quality Assurance Project Plan Phase III Remedial Investigation and Feasibility Study

52nd Street Superfund Site Operable Unit 3 Study Area
Phoenix, Arizona

August 2010

Project No. 96498

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LIST OF ACRONYMS

AAC	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
AWQS	Arizona Water Quality Standards
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of concern
CQAO	Consultant Quality Assurance Officer
CRQL	Contract required quantitation limit
^{o}C	Degrees Celsius
EB	Equipment blank
ERM	ERM-West, Inc.
FB	Field blank
FID	Flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
GIS	Geographic Information Systems
GPL	Groundwater Protection Level
HASP	Health and Safety Plan
HSO	Health and Safety Officer
IDW	Investigation-derived waste
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LTS	Lead Technical Support
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MHHSL	Modified Human Health Screening Levels
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology
NPL	National Priorities List
OERR	Office of Emergency and Remedial Response

OSHA	Occupational Safety and Health Administration
OU 1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PE	Performance Evaluation sample
PIC	Partner-in-Charge
PID	Photoionization detector
PM	Project Manager
PQL	Laboratory practical quantitation limit
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QA/QCM	QA/QC Manager
QAM	Quality Assurance Manual
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RL	Reporting limit
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
SOW	Statement of Work
SRL	Soil Remediation Level
SRM	Standard Reference Material
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
Working Group	Motorola 52nd Street Superfund Site Operable Unit 3 Working Group
WP	RI/FS Work Plan

1.0 INTRODUCTION

The Motorola 52nd Street Superfund Site is located in Phoenix, Arizona (Figure 1). The site was placed on the National Priorities List (NPL) in October 1989. The site is separated into three Operable Units (OU1, OU2, and OU3). The OU3 Study Area, which is hydraulically downgradient of OU2, has been established by United States Environmental Protection Agency (USEPA) and Arizona Department of Environmental Quality (ADEQ) to further determine the nature and extent of groundwater contamination between 20th Street and 7th Avenue (Figure 1).

ERM-West, Inc. (ERM) has prepared this Quality Assurance Project Plan (QAPP) on behalf of the Motorola 52nd Street Superfund OU3 Working Group (Working Group) as required by the Administrative Order on Consent (AOC). The Working Group is composed of Honeywell International, Inc. (Honeywell) and Arizona Public Service, a subsidiary of Pinnacle West. This QAPP has been prepared to ensure that the data collected are of sufficient quality to be used to characterize the OU3 Study Area, and specifically meet the needs of the Statement of Work (SOW). The QAPP together with the Field Sampling Plan (FSP) comprises the Remedial Investigation (RI) Work Plan (WP), which documents the methods, procedures, and rationale for Phase III groundwater RI activities (Phase III RI) at the Motorola 52nd Street Superfund Site OU3 Study Area.

The primary purpose of the WP is to conduct work set forth in the SOW as required by the AOC entered into between the Working Group and the USEPA with the effective date of 23 September 2009 (USEPA 2009). The AOC was issued under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The SOW anticipates the collection of the data necessary to complete an OU3 Groundwater RI Report and prepare a Feasibility Study (FS) WP for groundwater located in the OU3 Study Area. Field work in this Phase III RI will supplement prior investigations undertaken by USEPA to assess the lateral and vertical distribution of OU3 contaminants of concern (COCs) in groundwater, defined in Section 19 of the AOC as volatile organic compounds (VOCs) including trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, and VOC degradation by-products, cis-1,2-dichloroethylene, 1,1-dichloroethylene, vinyl chloride, 1,1-dichloroethane, and chloroethane. The RI will also evaluate the potential for migration of COC concentrations in groundwater into soil vapor, better define the hydrogeological parameters within the OU3 Study

Area, and collect the data to conduct a groundwater baseline risk assessment. Following completion and based on the findings of the OU3 RI Report, an OU3 FS WP will be prepared and implemented.

This QAPP details specific Quality Assurance and Quality Control (QA/QC) requirements that apply to the OU3 RI/FS. These QA/QC requirements are designed to assist in achieving analytical QA/QC objectives for all data collection that will be performed at OU3.

The guidelines for preparing this QAPP are presented in the document *EPA Requirements for Quality Assurance Project Plans* (USEPA 2001a). Based on this guidance document, the QAPP will be presented with the following format:

- Project Management – This section of the QAPP covers the basic areas of project management, including the project histories and cleanup objectives, and the roles and responsibilities of the project participants. The objective of this section of the QAPP is to define the project goals and approach, and to ensure that the project participants understand the goals and approaches to be used. This section also includes the management of project documents and records.
- Data Generation and Acquisition – This section describes all aspects of the project design and implementation. The implementation of these elements ensures that appropriate methods for sampling, measurement, analysis, data collection, data handling, and the field and laboratory QA/QC samples will be employed. It ensures proper documentation of all QA/QC activities.
- Assessment and Oversight – This section describes the data quality activities for assessing that the QAPP is being implemented as prescribed, and measures the effectiveness of the project implementation and all associated QA/QC activities.
- Data Validation and Usability – This section describes the data quality assessment methods to be used to evaluate field sample results against the established QA/QC objectives for measurement.

The intended purpose of this QAPP is to provide program QA/QC consistency at the OU3 site during all phases of the OU3 Focused RI/FS activities. Additional information on the data quality review process is described in the document *Guidance for Data Quality Assessment: Practical Methods for Data Analysis* (USEPA 2000a). This document provides the guidance to perform the scientific and statistical evaluation of the data to

ensure the project data objectives of quality and quantity are met to support project needs and their intended use.

This QAPP presents the guidelines for monitoring the performance of the analytical laboratory and is not intended to supersede the laboratory's QAPP. All project personnel will be required to read the QAPP. A copy of the QAPP will be kept with personnel during all field activities.

1.1 LOCATION AND HISTORY

This section briefly summarizes the Motorola 52nd Street Superfund Site history, describes the previous investigations conducted in the OU3 Study Area, and outlines the physical setting of the site. Figure 1 provides a site location map of the Motorola 52nd Street Superfund Site Study Areas.

The Motorola 52nd Street Superfund Site is approximately 7,800 acres and consists of three adjoining groundwater OUs: OU1, OU2, and OU3. OU1, approximately 1,000 acres, is the easternmost OU and contains the former Motorola 52nd Street semiconductor plant. The boundaries of OU1 are 52nd Street to the east, Palm Lane to the north, Van Buren Street to the south, and 44th Street to the west.

OU2 is approximately 3,800 acres, lies west of OU1, and contains the OU2 Groundwater Extraction System and several OU2 facilities of potentially responsible parties, including the Honeywell 34th Street facility. The approximate boundaries of OU2 are McDowell Street to the north, 44th Street to the east, Buckeye Road to the south, and the OU2 Groundwater Extraction System and 20th Street to the west.

OU3 is approximately 3,000 acres and lies west of OU2. The boundaries of the OU3 Study Area are McDowell Road to the north, the OU2 Groundwater Extraction System and 20th Street to the east, Buckeye Road to the south, and 7th Avenue to the west. The USEPA is the lead regulatory agency for OU3 and the OU2 Groundwater Extraction System. The ADEQ is the lead regulatory agency for OU1 and OU2.

2.0 PROJECT MANAGEMENT

2.1 PROJECT/TASK ORGANIZATION

2.1.1 Purpose and Background

Pursuant to the AOC with USEPA, the Working Group will complete a Phase III RI as described in the SOW included as Appendix A of the AOC. A complete description of OU3 and COCs is presented in the Phase III RI WP.

This QAPP has been prepared for the purpose of ensuring that the appropriate levels of QA/QC are maintained throughout the Phase III RI. The QAPP serves as the controlling mechanism during the RI/FS and provides the QA/QC techniques needed for sampling, sample handling and storage, chain-of-custody, laboratory analytical protocols, data validation, reporting, and documentation requirements. The QAPP also provides a summary of the project description, organization, and objectives. This QAPP is to be used in conjunction with the FSP submitted to and approved by the USEPA.

QA/QC procedures will be in accordance with applicable professional technical standards, USEPA requirements, ADEQ requirements, ERM's Quality Management Plan and specific project goals and requirements. This QAPP was prepared by utilizing the following: *Guidance for Data Quality Objectives (DQO) Process* (USEPA 2000b), *Requirements for Quality Assurance Project Plans* (USEPA 2001a), and *Guidance for Quality Assurance Project Plans* (USEPA 2002).

2.1.2 Roles and Responsibilities

The Working Group's contractor, ERM, will execute the SOW included in the AOC. Figure 2 provides the current project organization for implementation of the OU3 RI/FS. Since the individuals listed below may change over time, this QAPP has been written to include "designee" as an alternate to the current project organization. The ERM project team has been organized to provide clear lines of authority and communication that will expedite and enhance the flow of information vital to effective technical controls, cost, and schedule performance. The functional roles for personnel within this organizational structure are also clearly defined.

Individuals are given the authority to accomplish their respective project assignments. The following paragraphs define the functional responsibilities for the core ERM project team.

OU3 Working Group Project Managers - Ms. Troy Kennedy of Honeywell and Ms. Judith Heywood of Arizona Public Service, a subsidiary of Pinnacle West, are co-managers of the OU3 Working Group. The ERM project team, as represented by the Partner-in-Charge and Project Manager, reports directly to both OU3 Working Group Project Managers to execute the WP, which is written in accordance with the AOC dated 23 September 2009.

Partner-in-Charge – Mr. Robert Livermore is the Partner-in-Charge (PIC) for the OU3 RI/FS and will be the primary contact at ERM for the OU3 Working Group. As the designated PIC, Mr. Livermore is also the QA/QC Manager (QA/QCM) responsible for all work products and services performed on this project. The Project Manager (PM) and Analytical Program QA/QCM will report directly to the PIC. Team members generating, compiling, and evaluating project data, and providing other services in a technical, administrative or support function, report directly to the PM. Because the Analytical Program QA/QCM does not report to the PM, this role is not influenced by the individual direction daily line activities. Furthermore, the Analytical Program QA/QCM has direct access to the PIC, and thus can direct the project quality system and influence the project performance at the management level if required.

Analytical Program Quality Assurance/Quality Control Manager – The Analytical Program QA/QCM, Ms. Jill Quillin or designee, will ensure that analytical data are collected in a manner consistent with USEPA QA guidance and QAPP objectives. Ms. Quillin will be responsible for implementing the project analytical QA/QC program. She is responsible for laboratory coordination, data validation, and data quality assessment. The QA/QCM or ERM designee will be responsible for maintaining the QAPP. Ms. Quillin is the ERM corporate QA Officer.

Project Manager – Mr. David Abranovic, P.E. is the PM. He will be responsible for the coordination of the Phase III RI activities described in the FSP. All project-related activities will be addressed to the ERM PM. In addition, any updates or revisions recommended for future versions of the QAPP should be presented by the project team to the ERM PM. The ERM PM will notify the Working Group of any personnel or contractor changes.

Project Geologist – Mr. Jason Hilker, R.G., will act as Lead Geologist for this project and will report directly to the PM. Mr. Hilker will oversee all phases of field work at OU3.

Health and Safety Officer – The ERM Health and Safety Officer (HSO), Mr. Ron Brazeal or designee, reports to the ERM PM or directly to the Working Group if appropriate and will be responsible for final approval of the OU3 Health and Safety Plan (HASP) to ensure that health and safety procedures for the project are conducted in accordance with the Occupational Safety and Health Administration (OSHA) regulations and guidelines. The HSO will also be responsible for updating the HASP as needed, ensuring that proper health and safety procedures are followed, performing periodic field audits, and assigning site safety coordinators.

Database Manager and GIS Specialist – Mr. Mike Appel, or designee, will report to the ERM PM or PIC and be responsible for maintenance of the OU3 database and the Geographic Information Systems (GIS) component of the database. The GIS Specialist will be responsible for ensuring that the data are submitted to the ADEQ database in a compatible format. The GIS Specialist is responsible for creating, editing, and manipulating georeferenced spatial data to efficiently display OU3 information in a visual form. The GIS Specialist is responsible for producing high-quality maps via ArcGIS and AutoCAD.

Risk Assessor – The Risk Assessor, Mark Jones or designee, reports to the ERM PM or PIC and is responsible for providing a framework of risk information necessary to assist in decision-making during RI/FS activities. The framework is formed by analyzing baseline and residual site risks, determining levels of chemicals that are protective of human health, comparing health impacts of various remedial alternatives, and evaluating and documenting public health threats.

Field Personnel – ERM Field Personnel, report to the ERM PM and PIC, and are responsible for field activities including directing drilling, logging boreholes, overseeing installation of monitoring wells and vapor monitoring wells, and hydraulic testing. Field Personnel will coordinate with Lead Geologist Jason Hilker, R.G., to gather, interpret, and map technical data related to the project. The FM reports to the ERM PM and is responsible for field activity preparation and execution. This includes carrying out all sampling in accordance with approved procedures and methodologies; collecting all QA/QC samples; completing sampling forms, labels, and chain-of-custody forms; applying custody seals; and packaging and delivering or shipping samples to the laboratory.

Laboratory Project Manager – As Laboratory PM, Ms. Kylie Emily, will coordinate with the Analytical Program QA/QCM. Analytical services will be subcontracted, as required, to meet the requirements of the SOW. The laboratory will be accredited by the National Environmental Laboratory Accreditation Conference Institute, and will be certified by Arizona Department of Health Services (ADHS). The laboratory is designated as the primary analytical subcontractor and will perform the analyses for the standard analytical methods. Key positions and quality related responsibilities for laboratory personnel are discussed in the laboratory Quality Assurance Manual (QAM). The laboratory certifications are located along with the laboratory QAM in Appendix A.

Laboratory Quality Assurance Manager – The laboratory Quality Assurance Manager, Ms. Elizabeth Wueschner, or designee, is the QA Manager for Test America. The QA Manager will be responsible for implementing the laboratory's QA/QC programs, as described in the laboratory QAM.

Field Subcontractors – ERM-approved subcontractors may be utilized for the advancement of soil borings, soil vapor surveys, installation and sampling of groundwater and soil vapor monitoring wells, excavation activities, trenching activities, surveying, and other miscellaneous field activities. Major ERM project subcontractors are shown on Figure 2, and are listed in Section 8 of the WP. All subcontractors will comply with the OU3 RI/FS, QAPP, FSP, HASP, and WP.

2.2 *PROJECT DESCRIPTION AND REGULATORY CRITERIA*

2.2.1 *Project Description*

The following field investigation activities to be conducted for the OU3 RI/FS include:

- Soil vapor monitor well installation;
- Soil vapor sampling;
- Soil sampling;
- Groundwater monitor well installation;
- Aquifer testing;
- Groundwater sampling; and

- Water level measurements.

These activities are described in detail in the FSP.

If additional investigation activities not included in the current scope of work become necessary, similar analytical parameters and testing protocols will be supplemented as revisions to this QAPP.

2.2.2 *Criteria*

Criteria to be considered include advisories, criteria, or other guidance that do not have the status of laws or regulations, but the USEPA and the ADEQ have agreed are appropriate for protection of human health, or the environment, or to carry out certain actions or requirements. Preliminary OU3 COC-specific criteria for the OU3 RI/FS may include:

- Federal Maximum Contaminant Levels (MCLs) for drinking water promulgated in the Safe Drinking Water Act, Title 40 of the Code of Federal Regulations (CFR) Part 141. These Applicable or Relevant and Appropriate Requirements (ARARs) establish treatment standards for drinking water and are used as default groundwater cleanup standards by the USEPA. MCLs apply to groundwater at the site.
- Arizona Numeric Aquifer Water Quality Standards (AWQSs) promulgated in Arizona Administrative Code (AAC) R18-11-406. These ARARs establish default cleanup standards for groundwater in Arizona, are used by the ADEQ, and are nearly identical to federal MCLs. AWQSs apply to groundwater at the site.
- Maximum concentration of contaminants for the toxicity characteristic promulgated in Resource Conservation and Recovery Act (RCRA) regulations, 40 CFR 261.24. This ARAR provides for the definition of hazardous waste due to the leachability of certain organic and inorganic materials and may apply to soil excavated for off-site disposal.
- Region 9 Soil Vapor Screening Levels as represented by the Motorola 52nd Street Modified Human Health Screening Levels (MHHSLs). The MHHSLs were promulgated by USEPA Region 9 and represent the concentration of chemicals understood to be below the threshold of concern for risks to human health for the site. Specific MHHSLs are provided for selected chemicals in groundwater, indoor air, and soil gas. MHHSLs are used in this QAPP as screening levels for vapor-phase data.

- Arizona Soil Remediation Levels (SRLs) promulgated in AAC R18-7, Appendix A. These ARARs establish default soil cleanup levels that are protective of human health from dermal exposure or ingestion. AAC R18-7 also provides for alternative remedial standards using background concentrations or site-specific risk assessment. All SRLs (default or alternative) apply to soil left in place. Default SRLs apply to soil that may be excavated for off-site disposal.

2.3 MEASUREMENT QUALITY REQUIREMENTS

This QAPP has been prepared to ensure that the data collected are of sufficient quality to be used to characterize the OU3 Study Area, and specifically meets the needs of the SOW. This section of the QAPP details specific QA/QC requirements that apply to the OU3 RI/FS. These QA/QC requirements are designed to assist in achieving analytical QA/QC objectives for all data collection that will be performed at OU3.

More specifically, the measurement quality objectives include:

- Meeting the laboratory or method-specific criteria for reproducibility of laboratory analysis;
- Meeting the acceptable range of recoverability for each laboratory analytical method as compared to certification limits;
- Ensuring that the data generated during the execution of the scope of work are complete and that the laboratory data packages contain all the information necessary to determine the validity of the data;
- Ensuring that the practical quantitation limits (PQLs) for the specific methods using the analytical laboratory specific-procedures are sufficient to meet regulatory criteria; and
- Ensuring that the methods used to collect, analyze, and validate the data will yield results comparable to project data from other sites, using the best management practices provided in this QAPP.

These objectives are evaluated by monitoring the precision, accuracy, completeness, sensitivity, representativeness, and comparability as described in the following paragraphs.

2.3.1 *Precision*

Precision refers to the agreement or reproducibility of a set of duplicate or replicate results obtained from independent analyses completed under identical conditions. Both sampling and laboratory precision will be evaluated by the performance of field duplicates, matrix spike/matrix spike duplicates (MS/MSDs), laboratory duplicates, and Laboratory Control Samples/Laboratory Control Sample Duplicates (LCS/LCSDs).

Precision is expressed as the relative percent difference (RPD) in concentration between the original and duplicate analyses, as determined in the formula:

$$RPD = \frac{|S - D|}{\frac{1}{2} \times (S + D)} \times 100$$

Where:
RPD = Relative percent difference;
S = Concentration of analyte in the original sample; and
D = Concentration of analyte in duplicate sample.

Method-specific criteria for RPDs for groundwater and soil vapor analytes are listed in Tables 1 and 2, respectively. For data validation (see Section 5.0), the most stringent criteria will be used: either the laboratory-specific criteria or the method specific criteria.

2.3.2 *Accuracy*

Accuracy, or measurement bias, is a measure of the agreement between an experimental or observed value and the true value of the parameter being measured. A measurement is evaluated for accuracy by comparing a given observed value to a true value and against an established range specifying a lower limit and an upper limit of acceptability. LCS/LCSDs, surrogate spikes, and MS/MSDs will be used to evaluate the accuracy and bias for the project samples.

Accuracy is expressed as percent recovery (%R), as determined from the formula:

$$\%R = \frac{SSR - SR}{SA} \times 100$$

Where:

%R = Percent recovery (percent);

SSR = Spike sample result (concentration units);

SR = Original sample result (concentration units); and

SA = Spike added (concentration units).

Method-specific criteria for recoveries are listed in Table 3. For data validation (see Section 5.0), the most stringent criteria will be used: either the laboratory-specific criteria or the method specific criteria.

2.3.3 *Completeness*

Completeness is a measure of the adequacy of the amount of usable data resulting from the sampling and analysis program. It is evaluated for each method, matrix, and analyte combination in order to prevent misinterpretation of the data and to meet the needs of the sampling program. Another aspect of completeness involves the adequacy of the data package in documenting the associated QC data for the project samples. The validated data will provide a measure of completeness, but the usability of the validated data will be determined by ERM, the Working Group, and the USEPA. The completeness goal for this project is 90 percent; however, for critical samples the completeness goal will be 100 percent. Critical samples include those used to define the boundaries of areas requiring remediation or to demonstrate compliance with applicable federal or state criteria.

Percent completeness is expressed as %PC, as determined from the formula:

$$\%PC = \frac{N_A}{N_1} \times 100$$

NA = actual number of valid analytical results obtained.

N1 = theoretical number of results obtainable under ideal conditions.

2.3.4 *Sensitivity*

The method detection limit (MDL) is defined as the minimum concentration at which a given target analyte can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. Laboratory practical quantitation limits (PQLs), contract required quantitation limits (CRQLs) or reporting limits (RLs) are defined as the lowest level that can be reliably achieved within specified limits of

precision and accuracy during routine laboratory operating conditions. Laboratory MDLs and RLs will be used to evaluate the method sensitivity and/or applicability. To assess the respective method capability, the project criteria listed in Table 1 for each potential site related chemical have been screened against the CRQLs and RLs listed in Tables 4 and 5.

The sample-specific MDL and RL will be reported by the laboratory and will take into account any factors relating to the sample analysis that might decrease or increase the reporting limit (e.g., dilution factor, sample volume, sparge volume). In the event that the MDL and RL are elevated due to a matrix limitation and subsequent dilution or reduction in the sample aliquot, the data will be evaluated by ERM and the laboratory to determine if an alternative course of action is required. Should elevated RLs and MDLs continue to recur, the ERM PM shall consult with the USEPA and ADEQ prior to any corrective action.

2.3.5 *Representativeness*

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Rationale for the sampling effort is discussed in the FSP. The sampling plans and laboratory standard operating procedures (SOPs) will be followed to ensure that the requirements of the program design, sampling techniques, sample holding times, and analytical procedures are satisfied.

2.3.6 *Comparability*

Comparability represents the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability among measurements in these investigations will be achieved through the use of standard procedures for sample collection, handling, analysis, and reporting, as described in Section 3.0 of this QAPP and the procedures documented in the laboratory QAM.

2.4 *SPECIAL TRAINING REQUIREMENTS/CERTIFICATION*

All ERM and subcontractor field personnel on site shall have completed OSHA training in accordance with in 40 CFR 1910.120 and will have been trained regarding the requirements stated in this QAPP and the ERM HASP. Field auditors will require knowledge of this QAPP, FSP, WP, and site activities in order to provide a complete review of field procedures.

HASP. Field auditors will require knowledge of this QAPP, FSP, WP, and site activities in order to provide a complete review of field procedures.

All OU3 RI/FS analytical laboratories will maintain an Arizona Laboratory License through the ADHS. The ADHS licenses environmental laboratories engaged in compliance testing. Upon application for an environmental laboratory license, ADHS issues a license if they determine, after investigation, that the application conforms to their established standards. Otherwise, the laboratory must be certified or designated by the USEPA as a laboratory that provides analytical services to Arizona required for the delegation of primary enforcement responsibility under a federal law or regulation administered by that agency.

2.5 FIELD SAMPLING DOCUMENTATION

ERM will utilize the documents and reporting format outlined in this QAPP, the FSP, and the WP for recording information during project activities. Field team members will keep a daily record of significant events, observations, and measurements in a field log. Field documentation includes the field log, the groundwater sample collection log, the sample collection log, the visual classification of soils form, the well boring log, the monitoring well installation sheet, the instrument calibration log, the well development log, and chain-of-custody form. All documents generated during the field effort are controlled documents that become part of the project file. The forms are presented in Appendix A of the FSP.

2.6 PHOTOGRAPHS

Photographs will be taken at areas of interest during site investigation activities. They will serve to verify information entered in the field logbook. When a photograph is taken, the following information will be written in the logbook or will be recorded in a separate field photography book:

- Time, date, location, and, if appropriate, weather conditions;
- Type of camera;
- Description of the subject photographed (including the photograph direction); and
- Name of person taking the photograph.

2.7 SAMPLE IDENTIFICATION AND LABELING

Sample identification and labeling is important for maintaining the integrity of analytical data collected during the field investigation activities. The sample identification is an integral part of the data management for future analysis of data and further investigation responsibilities, if warranted.

Each sample will have an adhesive plastic or waterproof paper label affixed to the container and will be labeled at the time of collection. The following information will be recorded on the container label with a permanent marker at the time of collection:

- Project name;
- Sample identification;
- Date and time of sample collection;
- Preservative type (if applicable);
- Initials of sampler; and
- Laboratory analysis requested.

Along with the proposed soil vapor, soil, and groundwater samples, multiple QC samples will be collected to measure precision and effectiveness of laboratory, decontamination, and transportation procedures. The specific identification for these types of samples is described in the following sections.

2.7.1 Soil Vapor Sample Identification

Soil vapor samples from the monitoring wells will be uniquely identified with a sample identification that contains a reference to the sample matrix, soil vapor monitoring well number, type of sample, and date. The following is an example of the sample identification:

SV-MW-1D-022510-Q1

Soil vapor samples collected from the soil vapor monitoring wells will be broken down as in the following example:

Matrix	Location	Well	Date	Type
SV	MW	1A	022510	Q1

SV Indicates a soil vapor sample

MW Indicates the soil vapor sample is collected from a soil vapor monitoring well

1 Indicates the soil vapor monitoring well number (1, 2, etc.)

A Indicates the soil vapor well port at the existing monitoring wells:

Port A = Shallow screened interval

Port B = Intermediate shallow screened interval

Port C = Intermediate deep screened interval

Port D = Deep screened interval

022510 Indicates the date of the sample collection

Q1 Indicates the sample is a duplicate soil vapor sample

For example, SV-MW-1A-022510 is a soil vapor sample taken from Soil Vapor Monitoring Well 1, Port A, on 25 February 2010 at OU3. MS/MSD samples will not be collected for soil vapor.

2.7.2 *Soil Sample Identification*

Samples of soil core will be collected during the installation of vapor monitoring wells, and will be uniquely identified with a sample identification that contains a reference to the sample matrix, soil boring number, the sample depth, and type of sample. The following is an example of the sample identification:

SC-SVMW-1-25-35-022510

The sample identification is broken down in the following example to describe each of the components:

Matrix	Location	Well	Depth Interval	Date
SC	SVMW	1	25 - 35	022510

SC Indicates that the sample being collected is a soil core

1 Indicates the soil vapor monitoring well number installed during the investigation

25 Denotes sample collection depth interval below ground surface

For example, SC-SVMW-1-25-35 022510 is a soil sample taken from soil vapor monitoring well SVMW-1, from 25 to 35 feet below ground surface, on 25 February 2010 at OU3.

2.7.3 *Groundwater Sample Identification*

Groundwater samples will be collected from the existing and new monitor wells. The groundwater samples will be uniquely identified with a sample identification that contains sample matrix, monitor well number, geologic unit, and type of sample. The following is an example of the sample identification:

MW-1-S-022510-Q1

The sample identification is broken down in the following example, to describe each of the components:

Well ID	Hydrostratigraphic Unit	Date	Type
MW-1	Zone	022510	Q1

MW — Indicates that the sample being collected is from a monitor well

1 — Indicates the monitor well number installed during the investigation (1, 2, etc.)

S — Denotes the hydrostratigraphic unit from which the sample was collected. For example the units could be:

- S = Shallow Zone
- M = First Intermediate Zone
- D = Second Intermediate Zone

022510 — Indicates the date of the sample collection

Q1 — Indicates the sample is a duplicate water sample (only one duplicate groundwater sample is proposed per event)

For example, MW-1-S-022510 is a groundwater sample taken from Monitor Well MW-1, on 25 February 2010, from the Shallow Zone at OU3.

2.7.4 *QA/QC Sample Identification*

QA/QC samples to be collected will include field duplicates, MS/MSDs, field blanks, equipment rinsate blanks, Performance Evaluation (PE) samples, trip blanks, and split samples. These samples will be designated with the sample type designations listed below:

Q1	= Field duplicate sample
MS/MSD	= Sample for matrix spike/matrix spike duplicate preparation
R1	= Field Blank
EB	= Equipment Blank
Z1	= Performance Evaluation sample
L1	= Trip Blank
S	= Split sample

The field duplicate will be a blind duplicate identified with a false sample identification following the format discussed in the previous subsection. MS/MSD samples will be identified with the matrix, boring, and depth identifiers for the parent sample with MS and MSD as the type component. For example, SB1-25MS/MSD is the matrix spike sample collected from soil boring SB-1 from 25 feet bgs. Field blanks will be designated with FB, numbered sequentially, and identified by the date of collection. For example, the first field blank collected on 24 January 2010 will be R1-1-012410.

Equipment blanks will be designated with R1, numbered sequentially, and identified by the date of collection. For example, an Equipment blank collected on January 24, 2010 will be R1-1-012410. Trip blanks will be identified by the date samples were first placed in the cooler and the cooler number. For example, L1-1-012410 is the trip blank in Cooler 1 that was in use for sample storage starting on January 24, 2010. Performance Evaluation samples will be designated with PE, numbered sequentially, and identified by the date of collection. For example, a PE sample collected on 24 January 2010 will be Z1-1-012410.

2.7.5 *Investigation-Derived Waste (IDW) Sample Identification*

Investigation-derived waste will consist of two media, soil or water. IDW soil may include drill cuttings and soil samples. IDW water will include: groundwater sampling purge water, decontamination water and/or monitor well development water.

Below is an example of IDW sample identification:

IDW-W-032510

The sample identification is broken down in the following example to describe each of the components:

Sample Type	Sample Media	Date
IDW	W	032510

IDW = Investigation-derived waste sample
W = Water media
S = Soil media
032510 = Indicates date of sample

For example, IDW-W-032510 is an IDW sample taken from purge water on 25 March 2010 at OU3. Procedures for IDW sample collection are presented in Section 3.2.4.

2.8 *FIELD LOGBOOK DOCUMENTATION*

Field logbooks will be the main source of field documentation for all field activities. The on-site field representative will record in the field logbook information pertinent to the investigation program. The sampling documentation will contain information on each sample collected, and will include the following information:

- Project name;
- Field personnel on site;
- Facility visitors;
- Field observations and any deviations from the FSP;
- Maps, listing of photographs taken, and/or drawings;
- Date and time sample collected;
- Sampling method and description of activities; and
- Deviations from the QAPP and FSP.

The books will be permanently bound and durable for adverse field conditions. All pages will be numbered consecutively. All pages will remain intact, and no page will be removed for any reason. Notes will be taken in indelible waterproof, blue or black ink. The front and inside of each field logbook will be marked with the project name, number, and logbook number. The field logbooks will be stored in the project files when not in use and upon completion of each sampling event.

At the beginning of each day, the first entry in field logbook will include the date and time, project number, names of all field personnel (including subcontractors and the company for which they work), and the purpose of fieldwork. Each subsequent page will be started with the page number and the date. The bottom of each page will have the initials of all personnel entering information onto that page. Any remaining unused lines will be crossed through. Errors will not be erased, but will have a single strikethrough. Changes will be dated and initialed by the person making the change.

The following sampling forms and equipment logs will be used during the investigation process; the forms are presented in Appendix A of the FSP:

- Soil Vapor Sampling Form (used during soil vapor sampling);
- Soil Boring Log (used for the lithologic description of the soil boring cuttings);
- Well Construction Diagram (used for final details for the soil vapor and groundwater monitor wells);
- Well Development Data Logs (used during the development of the proposed monitor wells);
- Groundwater Sampling Form (used during the groundwater monitoring program sample collection);
- Instrument Calibration Log (used for the daily field equipment calibration record keeping, if applicable); and
- Water level measurement forms.

2.9 HARD COPY ANALYTICAL RECORDS REQUIREMENTS

For all analyses, the data reporting requirements will be restricted to those items necessary to complete data validation based upon the summary QC forms. However, all raw data must be available if requested and will be required for a portion of the data. The hardcopy deliverable requirements are:

- A case narrative listing the laboratory Arizona certification number, discussing analytical problems, if any, and referencing or describing the preparation and analytical procedures and instrumentation used; in addition, the samples associated with the deliverable should be listed.

- Chain-of-custody forms.
- Sample log-in/receipt records.
- Tabulated results, including final dilution volume of sample extracts, percent solids for solid samples, and concentrations of compounds of interest.
- Tabulated QA/QC sample results.
- All data qualification codes assigned by the laboratory, their description, and explanations for all departures from the analytical protocols.
- Method blanks associated with each sample, quantifying all compounds of interest identified in these blanks.
- Recovery assessments and replicate sample summaries. Laboratories should report all surrogate spike recovery data as appropriate, for each sample, and a statement of the range of acceptable recoveries should be included in reports using these data.
- Internal standard recovery assessments. Laboratories should report all internal standard spike recovery data as part of their Level IV data package, for each sample.
- Laboratory control samples associated with each sample, quantifying all compounds of interest, and a statement of the range of acceptable recoveries should be included in the report.
- Instrument calibration for each instrument, including:
  - Gas chromatograph/mass spectrometer tuning, if applicable;
  - Initial calibration and continuing calibration, as necessary for completion of the Level IV data package; and
  - Quantitation Limit or Contract Required Detection Limit Verification, if applicable.

Other miscellaneous information including raw data as necessary to completely document the analyses (for example, run logs, sample preparation logs, quantitation sheets, total ion chromatograms, spectra, etc.) will be required for those samples receiving full validation. These samples will be identified at the time of submittal to the laboratory.

All pages included in the data package, as well as the case narrative, results, custody information, and any or all sample specific narrative should be paginated, with no breaks in the numbering sequence. All data

shall be fully restorable from electronic backup and available upon request within 10 business days. Other laboratory record retention policies are described in the laboratory QAM.

2.10 PROJECT RECORD MAINTENANCE AND STORAGE

Project records will be secured by ERM until the end of the project, at which time all project records will be delivered into the possession of the OU3 Working Group, or until 10 years have passed after remediation construction. Each project team member is responsible for filing all necessary project information or providing it to the person responsible for the filing system. Individual team members may maintain files for individual tasks but must provide such files to the central project files upon completion of each task. A project specific index of file contents is to be kept with the project files. Hard copy documents will be kept on file at the ERM office throughout the duration of the project, and all electronic data will be maintained in the OU3 database at ERM.

3.0 DATA GENERATION AND ACQUISITION

The purpose of the QA program is to produce reliable data, ensure and provide ongoing control of data quality, evaluate data quality through data quality indicators, and provide applicable, quantitative data for analysis, interpretation, and decision-making.

3.1 SAMPLING PROCESS AND DESIGN RATIONALE

The plan schedule, rationale for the sampling design, and design assumptions for locating and selecting environmental samples (sampling locations, frequencies, rationale for selection) are detailed in the WP and FSP.

3.2 FIELD ACTIVITY METHODS REQUIREMENTS

The requirements and procedures for performing field sampling activities are summarized in the following sections. Reporting limits current for the submittal date of this report for soil vapor and groundwater analytical methods are provided in Appendix B. These limits are subject to change on a semiannual basis with laboratory updates and maintenance.

3.2.1 Groundwater Sampling

Groundwater sampling will follow the sample collection procedures described in the FSP. In general, all monitor wells will be purged prior to sampling to ensure that samples contain representative formation water. During purging, water quality field parameters will be collected to determine when the well has stabilized and sampling can begin. Any exceptions or additions to the FSP procedures will be documented in the field logs including the reason for the change and approvals of changes.

3.2.1.1 Sample Containers and Preservation Techniques

Analytical groundwater samples will be collected from each monitoring well. The samples will be placed into laboratory-supplied containers and preserved as required. Applicable container requirements, sample volumes and preservation methods are summarized in Table 6. All

preservation liquids will be added to the appropriate containers by the laboratory prior to shipment to the field.

3.2.1.2 *Field Quality Control Sampling*

QC sampling will include the collection of duplicate samples, MS/MSD samples, field blanks, equipment rinsate blanks, trip blanks, and PE samples.

- Split samples will be collected if requested by USEPA for analyses by a laboratory of their selection.
- Duplicate samples will be collected simultaneously with the parent analytical samples from a well or boring considered likely to exhibit contamination. Duplicate samples will be collected at a 10 percent frequency. The duplicates will be labeled according to Section 2.7 and will be submitted with sample collection time and date information. The duplicate sample will be submitted for the same analytical parameters as the parent sample.
- If required by the USEPA, split samples will be collected and provided directly to the USEPA for shipment and analysis. The split samples will be labeled according to Section 2.7.4.
- A field blank and equipment blank will be collected at the initiation of each sampling event and at other times described in Section 3.5.1. Equipment blanks will be collected daily for each type of decontamination process utilized in the sampling of site media. If the source water for the decontamination process changes, a new field blank must be collected.
- Trip blanks will be used in each sample cooler for field sampling.
- Temperature blanks will be used in each cooler submitted to the laboratory with site samples.
- Extra volume (typically two extra containers) for MS/MD samples will be collected for every 20 samples collected. MS/MSD samples will be collected at the same time as the parent sample from a well or boring expected to have low concentrations of the COCs. MS/MSD samples will be labeled as described in Section 2.7.4.
- One PE sample will be collected per groundwater sampling event to provide an external review of laboratory performance.

3.2.1.3 *Decontamination Procedures*

Non-dedicated groundwater water sampling equipment will also be decontaminated prior to its initial use and subsequently between each sampling location according to the following procedures:

1. The exterior of the pump or other non-dedicated equipment will be placed on a piece of Visqueen film and then washed with a power washer;
2. The exterior of the pump will be washed with Alconox®. Any piping or tubing used, such as a reel pump, will have Alconox sprayed on both the exterior and interior of the piping/tubing.
3. The Alconox-covered equipment will be washed by the power washer. All piping for the non-dedicated pump will be washed both inside and out. Dedicated tubing will be washed by circulating water though the tubing, via the discharge manifold, so that the Alconox flows through the tubing and out of the pump.
4. The pump will then be placed in a container containing distilled water only and rinsed. The pump will be allowed to run until approximately 5 gallons have been pumped. Any pumps not on dedicated tubing will have distilled water poured over them.
5. The electronic water level probe used for collecting water levels will be sprayed with a mixture of potable water and Alconox. The probe will be given a clean rinse using distilled water and allowed to air dry.

Decontamination fluids will be transferred to drums for temporary storage pending waste characterization and disposal. Residual sediments will be placed in roll-offs located in the designated area for characterization and disposal.

3.2.1.4 *Sample Storage and Shipment Procedures*

All water samples will be preserved at the time of sample collection. While awaiting packaging, water samples will be stored on ice in coolers. If samples cannot be shipped or delivered to a laboratory on the same day they are collected, they will be stored on ice at a minimum of 4 degrees Celsius (^{o}C) in a secure container and/or location and packaging will be delayed until the following morning so that the samples can be shipped with fresh ice. All water samples to be shipped or directly delivered to the laboratory for analysis will be prepared following procedures as detailed in Section 3.3.3.

3.2.2 *Soil Vapor Sampling*

Soil vapor samples will be collected following the sampling procedures described in the FSP. In general, all soil vapor monitoring wells will be installed and purged prior to sampling to ensure that samples are representative of subsurface conditions. Soil vapor monitoring well installation, purging and sampling will be completed in general accordance with the procedures set forth in *Advisory–Active Soil Gas Investigations* (California Regional Water Quality Control Board – Los Angeles Region [CRWQCB] 2003), *Interim Guidance for Active Soil Gas Investigations* (CRWQCB 1997), and *Soil Vapor Sampling Guidance* (ADEQ 2008). Any exceptions or additions to the SOPs or guidance documents will be documented in the field logs including the reason for the change and approvals of changes.

3.2.2.1 *Sample Containers and Preservation Techniques*

Soil vapor samples will be collected from each soil vapor monitoring well screen interval. The samples will be placed into Summa canisters. Split samples will also be collected in Summa canisters. Applicable container requirements, sample volumes, and preservation methods are summarized in Table 6. All soil vapor samples will be protected from the light and maintained at ambient temperature until the time of analysis.

3.2.2.2 *Field Quality Control Sampling*

QC sampling will consist of the collection of equipment blanks, field duplicates, and split samples. MS/MSD sample requirements are not applicable to air samples. Duplicate samples will be collected simultaneously with the parent analytical samples from a well considered likely to exhibit contamination. One soil vapor duplicate sample will be collected for every 10 soil vapor samples collected during the soil vapor survey. The duplicates will be labeled and will be submitted with sample collection time and date information.

All split samples will be collected in 1-liter Summa canisters and submitted to a fixed-base laboratory for USEPA Test Method TO-15 analysis. One soil vapor split sample will be collected for every 10 soil vapor samples analyzed by the laboratory.

3.2.2.3 Decontamination Procedures

The sampling of the soil vapor monitoring wells will utilize dedicated or disposable equipment; therefore, decontamination will not be required. Summa canisters will be cleaned by the laboratory between uses by three evacuation/pressurization cycles as detailed in USEPA Test Method TO-15. One canister from each cleaning batch will be filled with ultra-pure air and then analyzed to evaluate the effectiveness of the decontamination process by the fixed-based laboratory.

3.2.2.4 Sample Storage and Shipment Procedures

All soil vapor samples will be maintained at ambient temperature and pressure. The samples should be protected from exposure to light. Shipping procedures for soil vapor samples are detailed in Section 3.3.3.

3.2.3 Soil Sampling

Soil sampling will follow the procedures described in the FSP. In general, soil cores will be collected from the core barrel of the sonic drill rig. Geotechnical samples will be collected using a ring sampler. For IDW samples, En Core® or similar sampling devices could be utilized. Any exceptions or additions to the standard practice will be documented in the field logs including the reason for the change and approvals of changes.

3.2.2.1 Sample Containers and Preservation Techniques

IDW soil samples will be collected from discrete levels. The samples will be placed into laboratory-supplied containers and preserved as required. Applicable container requirements, sample volumes, and preservation methods are summarized in Table 6. All preservation liquids will be added to the appropriate containers by the laboratory prior to shipment to the field.

3.2.3.2 Field Quality Control Sampling

Quality control sampling will not be necessary for the IDW and/or geotechnical samples.

3.2.3.3 Decontamination Procedures

Drilling equipment including augers, drill bits, drill rods, and drill pipe will be decontaminated using a pressure washer prior to its first use and

prior to moving to each new drilling location. Pressure washing will be conducted in a designated area, which is to be lined with plastic sheeting. Decontamination fluids will be collected in the liner.

Other non-dedicated soil sample equipment, including split-spoon samplers, slide-bar samplers, brass sleeves, hand-augers, hand trowels, and other equipment used to collect soil samples, will be decontaminated using a three-bucket wash and rinse methodology by the following procedures:

- Spray, rinse, wash, and scrub equipment using a solution of Alconox® (or equivalent) and potable water contained in one 5-gallon bucket;
- Rinse with potable water in one 5-gallon bucket;
- Rinse with distilled water contained in one 5-gallon bucket; and
- Air-dry the equipment.

3.2.3.4 *Sample Storage and Shipment Procedures*

Three aliquots of each sample will be collected in an En Core®-sampler. While awaiting packaging, samples will be stored on dry ice in coolers. If samples cannot be shipped on the same day they are collected, they will be stored on dry ice in a secure container and/or location and packaging will be delayed until the following morning so that the samples can be shipped with fresh ice.

All soil will be prepared for shipment or delivery to the laboratory using procedures detailed in Section 3.3.3.

3.2.4 *Investigation-Derived Waste*

All IDW will be handled in accordance with USEPA Office of Emergency and Remedial Response (OERR) Directive 9345.3 02, *Management of Investigation Derived Wastes during Site Investigations* (USEPA 1991). To characterize IDW for transportation, disposal, or recycling, representative samples will be collected. The drill cuttings produced during the drilling activities will be collected using a tilt hopper and temporarily stored in roll-offs located in a secure area. The roll-offs will be lined with plastic tarps and drill cuttings will be covered with plastic at all times unless access is necessary to add sample material.

A composite soil sample will be collected from the roll-offs and submitted to the laboratory to provide representative sampling results for the waste stream. The composite sample will be analyzed for the following:

- VOCs using USEPA Test Method 8260B;
- Polynuclear aromatic hydrocarbons (PAHs) using USEPA Test Method 8310;
- RCRA 8 Metals, using USEPA Test Method 6010B/7471A;
- Chromium VI using USEPA Test Method 7196;
- Cyanide using USEPA Test Method 9010B;
- Polychlorinated biphenyls (PCBs) using USEPA Test Method 8082; and
- Pesticides using USEPA Test Method 8081A.

The analytical results will be used to characterize the waste and to establish a profile for special waste disposal at Butterfield Landfill or other appropriate disposal or recycling facility. IDW characterization analysis reporting limits are presented in Appendix B.

Well development water, purge water, and decontamination fluids will be contained and stored in a poly tank located in the staging area prior to discharge to the City of Phoenix sanitary sewer. Composite samples will be collected from the tank using disposable bailers to ensure collection of representative samples. The samples will be analyzed for the following:

- VOCs using USEPA Test Method 8260B;
- PAHs using USEPA Test Method 8310;
- PCBs using USEPA Test Method 8082; and
- Pesticides using USEPA Test Method 8081A.

These analytes are required for wastewater generated from the installation and development of new monitoring wells; this water will be segregated from purge water obtained during groundwater sampling, as required by Chapter 28 of the City of Phoenix Code. The analytical data or subsequent groundwater monitoring data will be used to characterize the wastewater and to apply for a City of Phoenix, Sanitary Sewer Discharge Permit for IDW water disposal in the City of Phoenix sanitary sewer system or to meet other appropriate disposal or recycling facility requirements. An alternative appropriate disposal or recycling facility may also be used to

properly transport and dispose of IDW water. IDW characterization analysis reporting limits are presented in Appendix B.

IDW personal protective equipment can be considered nonhazardous and disposed of as sanitary waste if the soil or water from the same source is determined to be non hazardous or to contain compounds at concentrations below levels of concern, based on the results of analytical testing. IDW that is determined to be a hazardous waste (including water, soil, and personal protective equipment) will be labeled appropriately and disposed of as a hazardous waste at a permitted Treatment, Storage, and Disposal Facility.

3.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

3.3.1 Sample Container Preparation and Handling

It is important to use the proper sample containers so that no chemical alteration occurs during field sampling and transit to the laboratory. The sample bottles will be prepared by the laboratory or commercial supplier using USEPA Methods, and shipped to the field by the laboratory or commercial supplier.

Sample containers will be selected to ensure compatibility with the sampled media and to minimize breakage during transportation. Sample labels will be filled out at the time of sampling and affixed to each container. Each label will identify the site name, the sample number, collector's initials, date and time of collection, preservatives added, and analyses to be performed. This same information will be placed on the chain-of-custody form.

All soil and water samples, and a temperature blank, will be placed in sample containers immediately after collection and then placed in a shipping container. Those samples requiring preservation at 4°C ±2ºC will be covered with ice in double plastic bags and placed in an insulated cooler. Double-bagged crushed ice will be added to the shipping coolers as the samples are collected. Samples collected for volatile organic analyses will be packaged together to minimize the need for trip and temperature blanks.

Sample type, sample preservation, container type, volume requirements, analytical methods, and extraction and analysis holding times are summarized in Table 7. Samples not preserved or analyzed in accordance

with these requirements may necessitate expediting the analysis (in the event the holding time is reduced) or may require re-sampling and re-analysis.

3.3.2 Custody Requirements

Chain-of-custody records are used to document sample collection and shipment to a laboratory for analysis. The chain-of-custody form is an integral component of the sampling process, and represents the permanent record of sample holding and shipment. Forms will be completed and sent with the samples for each laboratory and each shipment. If multiple coolers are sent to a single laboratory on a single day, forms will be completed and sent with each cooler.

The chain-of-custody record will identify the contents of each shipment and maintain the custodial integrity of the samples. A sample is considered to be in someone's custody if it is either in someone's physical possession and/or in someone's view. A locked seal will be placed across the front and back of each cooler containing samples when coolers are ready for shipment. All custody seals will be signed and dated. The chain-of-custody form will be crosschecked for errors and signed.

The ERM field representative will sign the "relinquished by" box and note the date, time, and air bill (if applicable). Until the samples are delivered, the custody of the samples will be the responsibility of the ERM field representative and will be kept in a secured area that is restricted to authorized personnel. A laboratory representative will check samples with their respective chain-of-custody form(s) into the laboratory, and the form will be signed and dated appropriately. The ERM field representative will retain one copy of the signed chain-of-custody form for the project files. The original chain-of-custody form will be returned to the project manager with the analytical results to go into the project files.

3.3.3 Shipment

Samples to be shipped to the laboratory will be properly packaged in individual plastic bags and cushioned with bubble wrap to prevent damage. They will be placed in a cooler with a signed chain-of-custody form, ice (double-bagged), and a temperature blank, and shall be cooled to less than 4°C ±2°C.

Samples may be shipped in coolers using an overnight courier, courier employed by the analytical laboratory, or delivered to the laboratory by

field personnel. The shipping procedures for soil and water samples will include the following steps:

- Place packing material (zonolite, vermiculite, bubble wrap, etc.) in the bottom of a waterproof cooler.
- Seal bottles in clear plastic bags and wrap each sample bottle using bubble wrap. Place sample bottles in cooler and introduce packing material around and between bottles to prevent the bottles from touching each other or the sides of the cooler.
- Place a temperature blank in the cooler.
- Double-bag the ice in plastic bags and pack in the cooler on and around bottles, especially around VOC samples.
- Fill the cooler with packing material.
- Sign and date the chain-of-custody form and place paperwork in plastic bags and attach with masking tape or duct tape to the inside lid of the cooler.
- Tape the drain shut.
- Close the cooler and secure the lid by taping the cooler completely around with strapping tape at two locations.
- Place the lab address on top of the cooler.
- Put "This Side Up" labels and "Fragile" labels on the cooler.
- Affix custody seals on the front right and back left corners of the cooler, sign and date the seals, and cover seals with wide, clear tape.
- Attach shipping papers to the cooler.

If samples are to be hand-delivered to the laboratory by field personnel, they should be sealed in plastic bags and placed securely in a cooler with double-bagged ice and with packaging material to protect them from breakage. A temperature blank is required. Chain-of-custody paperwork should be completed and dated, but it will not be necessary to affix custody seals or shipping labels on the cooler.

Upon shipment, the laboratory will be notified that a sample shipment is scheduled to arrive. An effort will be made to provide the laboratory with 1-week advance notice of sample shipment.

Soil vapor samples will be delivered or shipped at ambient temperature. Soil vapor samples collected in Summa canisters may be shipped via air

courier. Summa canister samples will be packed in cardboard boxes or other containers as provided by the laboratory. If the canister does not fit securely into the container, paper or other packing material will be used to prevent damage to the canister or valve during shipment. If samples are to be shipped by commercial courier, the signed and dated chain-of-custody form will be placed inside the container and appropriate custody seals and shipping labels affixed to the container.

Each shipping container will be clearly marked with a sticker containing the originator's address. Any coolers that are not hand delivered will be shipped priority for overnight delivery. Coolers that are not hand delivered to the laboratory will have a custody seal affixed to the shipping container so that the shipping container cannot be opened without breaking the custody seal.

Shipments of samples from the field to the laboratory will typically occur within 48 hours of collection. Samples requiring analyses with short holding times will be identified and designated as such on the chain-of-custody forms and will be shipped on the date of collection, if possible.

3.3.4 Laboratory Sample Custody

3.3.4.1 Laboratory Receipt and Log-In

The chain-of-custody form will be signed on receipt by the laboratory to fully complete the custody chain. The condition of the samples upon receipt by the laboratory is documented on a cooler receipt log or sample condition upon receipt form. This log will note sample integrity, preservation, temperature, custody seal condition, and will note any discrepancies between information on the sample labels and that on the chain-of-custody form.

Each sample will be logged into the laboratory system by assigning it a unique sample number. This number and the field sample identification number will be recorded on the laboratory report. Samples will be stored and analyzed according to specified USEPA Methods. A duplicate copy of the chain-of-custody form will be returned to the ERM PM for permanent storage.

3.3.4.2 Laboratory Sample Handling

Field samples may be held at the laboratory to form an analytical batch consisting of a maximum of 20 field samples that are of the same matrix or

of similar composition, with the constraint that the method extraction and analysis holding times are not exceeded or jeopardized. Unless prevented by matrix, associated QC samples, including trip blanks, field blanks, methanol blanks, equipment blanks, duplicates, and project-specific MS/MSDs, are to be extracted and analyzed with the field samples.

Soil and water samples shall be stored in limited access, temperature-controlled areas (refrigerators and coolers 4°C ±2°C, freezers less than 0°C), which are monitored for temperature during business days. Soil vapor samples shall be stored at ambient temperature. Samples for volatile organic analysis shall be stored separately from other samples, standards, and sample extracts. All of the cold storage areas shall be monitored by thermometers, which are to have been calibrated with a certified reference standard. (The laboratory QAM may be referenced for details regarding their sample storage policies and procedures).

The sample holding time begins with the date (and time for samples with holding times less than 48 hours) the sample is collected and continues until the date and time the sample analysis is complete. Sample type, sample preservation, container type, volume requirements, analytical methods, and extraction and analysis holding times are summarized on Table 6. Samples not preserved or analyzed in accordance with these requirements may necessitate expediting the analysis (in the event the holding time is reduced) or possible re-sampling and reanalysis. The laboratory PM shall be responsible for prioritizing work to assure that holding times and project commitments are met. Any discrepancies will be noted on the appropriate form, and the ERM PM, or designee, will be immediately notified.

If not entirely consumed during analysis, organic analytical samples shall be stored, at least, until the analysis holding time has expired. All other analytical samples shall be kept for at least 60 days after submittal of the laboratory report. After these dates, the laboratory may dispose of all analytical samples according to local, state, and federal regulations. Unless otherwise notified by ERM, samples may be disposed of 60 days after submittal if the specified laboratory report has been provided to ERM.

3.3.5 *Evidence Files/Document Custody*

The final evidence file will be the central repository for all documents, which constitute evidence relevant to sampling and analysis activities as described by this QAPP and include all relevant records, reports, logs,

field forms, pictures, and subcontractor reports. ERM will be responsible for the custody of the evidence files and maintain the contents of the files for the duration of the project. No files shall be destroyed except exact identical copies. Files shall be maintained through the end of the project, or for 10 years after remediation construction has been completed, whichever comes first. For additional details regarding the storage and return of OU3 Study Area files to the USEPA, please refer to the AOC (USEPA 2009).

3.4 ANALYTICAL METHODS REQUIREMENTS

All groundwater samples, soil samples, and soil vapor samples from monitoring wells collected during field sampling will be analyzed by a fixed-base laboratory. The project samples and associated field and laboratory QC samples will be collected, preserved, and analyzed in accordance with USEPA or American Society for Testing and Materials (ASTM) methods. The extraction/digestion procedures and the associated analytical methods are listed in Table 7, followed by a brief description of each method. The method and/or laboratory-specific QC acceptance criteria for the precision and accuracy for spiked sample pairs (LCS/LCSDs, and MS/MSDs) and the accuracy criteria for samples including surrogate spikes are shown in Table 8, Data Qualifiers, in which the qualifiers have been established by the ADEQ.

Recommended analytical methods have been chosen based on COCs documented in Table 4 and were determined based on the respective site histories and project objectives.

Laboratory test methods for the sampling program will include the following:

- VOCs by USEPA Method 8260B;
- SW-846 USEPA Test Method 8260B or TO-15;
- Semivolatile organic compounds by USEPA Test Method 8270C;
- Total petroleum hydrocarbons by Arizona Modified Test Method 8015 AZ R.1 (soil), GRO and DRO-ORO (groundwater);
- PAHs by USEPA Test Method 8310;
- Metals by USEPA Test Methods 6010B/7471A;

- Chromium VI by USEPA Test Method 7196 (soil) or 3500 (groundwater);
- Cyanide by USEPA Test Method 9010B;
- PCBs by USEPA Test Method 8082; and
- Pesticides by USEPA Test Method 8081A.

A complete description of soil, soil vapor, and groundwater analyses and the USEPA methods to be used are presented in Section 6.0 of the FSP.

3.5 QUALITY CONTROL REQUIREMENTS

The QC program verifies that data have been generated by technically sufficient practices. Field QC samples monitor the potential impact on reported results of sample collection activities, transport, and matrix effects, in conjunction with analytical performance. Laboratory QC samples monitor laboratory-induced contamination and analytical performance.

3.5.1 Field Quality Control Requirements

Field QC is monitored and enforced by means of field equipment calibration checks, the collection of QC samples, a review of QA/QC concerns identified in the field, and any corrective action required. These tasks will be performed by ERM personnel who are practiced with the field protocols. Compliance QC checks will be implemented during the investigations as outlined in Sections 4.1.1, and 4.3.1. Field sampling precision and data quality will be evaluated through the use of field blanks, trip blanks, methanol blanks, equipment rinsate blanks, blind duplicates, and MS/MSDs. Sample integrity during shipment is monitored with temperature blanks.

3.5.1.1 Field Blanks

Field blanks are samples containing an assumed, analyte-free matrix, and are collected at the same location and processed in the same manner as equivalent environmental samples. For example, a field blank taken with groundwater samples is collected by pouring analyte-free water into a sample container at the same physical location where the environmental sample is collected; the field blank is subsequently handled, processed, and analyzed exactly as an equivalent environmental sample. The field

blank is used to identify contamination resulting from field sample collection techniques or background ambient conditions. The source of the water used for field and equipment blanks will be identified in the field sampling logs or field notes. Field blanks must be collected at the beginning of the sampling event, upon a change in source water, and may be collected daily if deemed appropriate. Field blanks will be labeled according to Section 2.7.4.

Field blanks for the soil vapor sampling will be prepared by pulling ultra pure air through a length of tubing into a sampling container. The tubing shall be a clean section of the same tubing used for sample extraction. Field blanks will be collected daily for on-Site soil vapor analyses. Soil vapor field blanks will be labeled according to Section 2.7.4.

3.5.1.2 *Trip Blanks*

The trip blank for water and soil samples consists of a sample vial filled in the laboratory with reagent grade, analyte free water, transported to the sampling site in a sample cooler, handled like an environmental sample, and returned to the laboratory for analysis. The trip blank is used to detect any cross contamination of COCs during the shipment, handling, and storage of environmental samples. A trip blank will be shipped in every cooler containing environmental soil and water samples collected for VOC analysis.

Soil vapor trip blanks will be prepared by the laboratory on the days that split soil vapor samples are collected. Soil vapor trip blanks will be prepared by filling one 1-liter Summa canister with laboratory-grade, ultra-pure air before commencement of the day's sampling. The soil vapor trip blank will be stored with the other soil vapor samples collected in Summa canisters during that day.

3.5.1.3 *Equipment Blanks*

The equipment rinsate blank is a sample of reagent grade, analyte-free, water poured into, over, or pumped through the sampling device, collected in a sample container, and transported to the laboratory for analysis in the same manner as environmental samples. These blanks are used to assess the effectiveness of equipment decontamination procedures. Equipment rinsate blanks are prepared in accordance with ASTM D 5088-90 (Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites) protocol and are used to monitor the effectiveness of the decontamination process. One equipment rinsate

blank sample per type of sampling equipment utilized will be collected at the initiation of each sampling event where samples are submitted for COC analysis. The equipment rinsate blank shall be analyzed for the laboratory analyses requested for the environmental samples collected at the sampling location. Equipment rinsate blanks will be labeled according to Section 2.7.4.

All soil vapor sampling equipment is disposable; therefore, no equipment blank is necessary. If required, the equipment blank for soil vapor samples will be prepared by drawing clean ambient air through the entire sampling train following decontamination and filling a sample container of the same type as used for sample collection with clean ambient air.

3.5.1.4 *Duplicates*

Duplicate samples are collected to monitor the precision of the field sampling and analytical process as well as to provide information regarding the homogeneity of the sample matrix. One duplicate sample will be collected for every 10 environmental samples per matrix. A control limit of ±20 percent for water and ±50 percent for the soil vapor and soil RPD shall be used when both the sample and field duplicate results are greater than or equal to 5 times the CRQL or RL. A control limit of ±PQL for water and ±2 times the PQL for soil vapor and soil shall be used when at least one of the results is less than 5 times the CRQL or RL.

Soil Vapor

Duplicate Samples: Soil vapor duplicate samples will be collected during the soil vapor sampling approximately every 10 samples or at least one per day. One soil vapor sample duplicate will also be collected during the sampling of the new and proposed soil vapor monitoring wells. Duplicate samples will be collected from areas of concern by the following procedures:

A. Duplicate samples will be collected in separate sample containers, at the same port; and

B. Duplicate samples will be collected immediately after the original sample.

All soil vapor duplicate samples will be collected by using the same procedures described in Sections 5.4.3 and 5.4.5 of the FSP.

Split Samples: Split samples will be collected by the USEPA with 14-day advance notice to the ERM project team. A typical frequency is one sample per event. The split samples will be collected in Summa canisters by the procedures described in Section 5.10.2 of the FSP and submitted to the fixed-base laboratory for analysis using USEPA Test Method TO-15.

Groundwater

A groundwater duplicate sample will be collected during each round of sampling of the monitoring program. The duplicate samples will be collected with the parent analytical samples from the well most likely to exhibit the highest levels of VOCs. Duplicate samples will be collected in separate sample containers.

Groundwater will be analyzed for VOCs by USEPA Test Method 8260B, and three 40-milliliter vials are required for each sample. When retrieving a groundwater sample and a sample duplicate, six 40-milliliter vials will be filled. Vials labeled for the parent sample will be used to collect the first, third, and fifth vials; vials labeled for the field duplicate will be the second, fourth and sixth vials collected.

3.5.1.5 *Matrix Spike/Matrix Spike Duplicate*

MS/MSD samples are collected to measure the precision and accuracy of both the field sampling and laboratory analysis as well to serve as an indicator for the presence or absence of matrix effects. This measure is required for soils and waters but is not applicable to soil vapors. Extra volume (typically two extra containers) for one site sample will be collected for every 20 environmental samples for soils and waters. The extra volume is submitted to the laboratory for MS/MSD analysis. MS/MSD samples will be analyzed by the same methods as the environmental samples and are discussed further in Section 3.5.2 under "Laboratory Quality Control Requirements."

3.5.1.6 *Performance Evaluation Samples*

PE samples for water will be included as a program QA measure. One PE sample will be collected per groundwater sampling event. This sample will be obtained from a commercial vendor and will contain certified concentrations of the target compounds which are anticipated to be identified at OU3. The PE sample will be submitted to the laboratory double-blind; the sample will be introduced into the sampling stream in the field and will be analyzed by the laboratory without the laboratory's

knowledge of its significance. Vendor-supplied control limits will be used to evaluate the results of the PE sample analysis with respect to proper identification of the spiked compounds and the acceptability of the resulting quantification. Any necessary corrective action will be based upon the severity of the deficiency in the identification and quantitation of the spiked target compounds. Corrective action may include up to rejection of the data for that compound or class of compounds.

3.5.1.7 *Temperature Blank*

The temperature blank is a vial provided by the laboratory that is partially filled with water. At the time of sample receipt, the laboratory measures the temperature of the vial contents as a measure of the sample preservation conditions. If the temperature falls outside the required range of 4°C ±2°C, preservation has not been within method requirements and data may need to be qualified during validation.

Quality Control Sampling Program

	Water	Soil Vapor
Duplicate	1 every 20 samples	1 per every 10 samples collected, minimum of 1 per day
Split	upon request	upon request
Field Blank	1 per event or change in source water	1 per 10 samples, minimum of 1 per day
Equipment Rinsate Blank	1 per type of sampling equipment per day	NA
VOC Trip Blank	1 per cooler	1 per cooler
MS/MSD	1 per every 20 samples	NA
Performance Evaluation	1 per every groundwater sampling event	NA
Temperature Blank	1 per cooler	NA

3.5.2 *Laboratory Quality Control Requirements*

The laboratory QAM lists the SOP format and both the QAM and SOP discuss the laboratory quality control samples that will be evaluated to meet the data quality requirements of the analytical methods. The laboratory shall be responsible for assuring that the precision and accuracy criteria are met and maintained in accordance with method specifications, followed by the appropriate corrective action, cited in

Table 1, when necessary. In the event corrective action is warranted, the laboratory will provide the appropriate documentation, such as a nonconformance report (NCR) or data qualifiers, and report the problem in the laboratory case narrative. In general, should there be a disagreement between the QAPP and the laboratory QAM, the project QAPP will take precedence, and every attempt will be made to resolve such differences, as needed. The laboratory control limits for the QC samples and method QC indicators are cited in Table 1.

3.5.2.1 *Laboratory Control Sample*

The LCS is a sample of analyte-free water or other clean matrix spiked with known concentrations of all analytes listed in the QC acceptance criteria tables for each method. Each analyte in the LCS is to be spiked at a level less than or equal to the midpoint of the analyte calibration curve.

For most organic methods, the LCS is prepared in duplicate (LCSD) and serves as an indicator of both accuracy and precision of the analytical process. The LCS will be carried through the complete sample preparation and analysis procedure along with the project samples in order to evaluate each analytical batch and to determine if the method is in control. The LCS cannot be used as the continuing calibration verification.

3.5.2.2 *Matrix Spike/Matrix Spike Duplicate*

The MS/MSD is an aliquot of an environmental sample spiked with known concentrations of the analytes listed in the QC acceptance criteria tables for each method. MS/MSD requirements are not applicable to soil vapor samples due to the limitations of the matrix and analytical methods. The spiking occurs prior to sample preparation and analysis. Each analyte in the MS/MSD shall be spiked at a level less than or equal to the midpoint of the analyte calibration curve.

Although the results of the project MS/MSDs are not used to control the analytical process, they are used to evaluate sample bias due to matrix. The performance of the MS/MSD is evaluated against the QC acceptance criteria tables for each method.

3.5.2.3 *Method Blank*

The method blank is a sample of analyte-free water or other clean matrix to which all reagents are added in the same volumes or proportions as are used in sample processing. The method blank monitors the presence or

absence of contaminants originating from the laboratory and shall be provided with each analysis and/or extraction batch. Method blanks for soil vapor samples will be prepared by filling a sampling container of the same type as used for field samples with ultra-pure air and then analyzing in the same manner as a sample.

3.5.2.4 Holding Blank/Storage Blank

A holding blank is reagent water that is stored with samples in an analytical batch. It is analyzed after all samples in the batch and is used to determine the level of contamination acquired during storage. Holding blanks are prepared for soils and waters submitted for volatile organic analyses.

3.5.2.5 Surrogates

Surrogates are organic compounds that are similar to the target analytes in chemical composition and behavior, but that are not normally found in environmental samples. Surrogates shall be added to environmental samples, controls, and blanks, in accordance with the method requirements in order to evaluate accuracy, method performance, and extraction efficiency. The surrogate recovery criteria shall be as listed in Table 1.

3.5.2.6 Internal Standards

Internal standards are measured amounts of certain compounds added after sample preparation or extraction. They are used in an internal standard calibration method to correct sample results for analysis efficiency. Internal standards shall be added to environmental samples, blanks, standards and QC samples, in accordance with method requirements.

3.5.2.7 Quantitation

Organic samples quantitated between the MDL and the RL will be reported with the appropriate laboratory qualifier (E). The lowest possible dilution shall be performed for all sample analyses in order to achieve the project objectives.

3.6 INSTRUMENT AND EQUIPMENT MAINTENANCE

3.6.1 Field Instruments

In accordance with the QA program, ERM shall maintain an inventory of field instruments and equipment. The frequency and types of maintenance will be based on the manufacturer's recommendations and/or previous experience with the equipment.

The ERM PM will be responsible for the preparation, documentation, and implementation of the preventative maintenance program. All maintenance records will be checked according to the schedule on an annual basis and recorded by the responsible individual. The ERM QA/QCM or designee shall be responsible for verifying compliance.

3.6.2 Laboratory Instruments

In accordance with the QA program, the laboratory shall maintain an inventory of instruments and equipment and the frequency of maintenance based on the manufacturer's recommendations and/or previous experience with the equipment.

The laboratory preventative maintenance program that is organized to maintain proper instrument and equipment performance and to prevent instruments and equipment from failing during use can be reviewed in the laboratory QAM. The program considers instrumentation, equipment and parts that are subject to wear, deterioration, or other changes in operational characteristics, the availability of spare parts, and the frequency at which maintenance is required. Any equipment that has been overloaded, mishandled, gives suspect results, or has been determined to be defective will be taken out of service, tagged with the discrepancy noted, and stored in a designated area until the equipment has been repaired. After repair, the equipment will be tested to ensure that it is in proper operational condition. ERM will be promptly notified in writing if defective equipment casts doubt on the validity of analytical data.

Laboratory Group Supervisors will be responsible for the preparation, documentation, and implementation of the preventative maintenance program. All maintenance records will be checked according to the schedule on an annual basis and recorded by the responsible individual.

The laboratory QA Officer, or designee, shall be responsible for verifying compliance.

3.7 INSTRUMENT AND EQUIPMENT CALIBRATION

Proper calibration of equipment and instrumentation is an integral part of the process that provides quality data. Instrumentation and equipment used to generate data must be calibrated at a frequency that ensures sufficient and consistent accuracy and reproducibility.

3.7.1 Field Instrument and Equipment Calibration

Field equipment will be calibrated prior to each sampling event according to manufacturer's recommendations using manufacturer's standards. The equipment, calibration, and maintenance information will be documented in the instrument calibration log (Appendix A of the FSP). The frequency of calibration is dependent on the type and stability of the equipment, the calibration method, the intended use of the equipment, and the recommendations of the manufacturer. Detailed information regarding the calibration and frequency of equipment calibration is provided in specific manufacturer's instruction manuals.

The primary field instruments requiring calibration are the photoionization detector (PID) or flame ionization detector (FID), and the Water Quality Meter that measures pH, conductivity, and temperature. ERM personnel will calibrate these instruments daily in accordance with the manufacturer's specifications. Equipment that fails calibration or becomes inoperable during use will be removed from service and tagged (time and date of action) to prevent inadvertent use. Such equipment will be satisfactorily recalibrated or repaired and tagged (date and time of return to service) prior to use.

3.7.2 Laboratory Instrument and Equipment Calibration

As part of its QC program, the laboratory performs two types of calibrations. A periodic calibration is performed at prescribed intervals (i.e., balances, drying ovens, refrigerators and thermometers), and operational calibrations are performed daily, at a specified frequency, or prior to analysis (i.e., initial calibrations) according to method requirements. Calibration procedures and frequency are discussed in the laboratory QAM. Calibrations are discussed in the laboratory SOPs for analysis.

The laboratory QA Officer will be responsible for assuring that the laboratory instrumentation is calibrated in accordance with specifications. Implementation of the calibration program shall be the responsibility of the respective laboratory Group Supervisors. At a minimum, each supervisor must address the following key points for the applicable instruments in their areas of responsibility:

- Recognized procedures (USEPA, ASTM, or manufacturer's instruction) shall be used when available. Written calibration procedures may include the reference materials to be used, calibration technique, acceptable performance limits, frequency, and documentation.
- All target analytes reported shall be present and in the range of acceptable calibrations.
- Clear documentation of all calibration standards and standards preparation used in the calibration and quantification of project samples will be maintained.
- All equipment that is subject to calibration shall be labeled with a unique number.
- Calibration frequency shall be determined by manufacture's recommendations, agency requirements, type of equipment, instrument stability, type of method, or prior experience.
- Physical standards (i.e., weights or certified thermometers) shall be traceable to nationally recognized standards such as the National Institute of Standards and Technology (NIST).
- Chemical reference standards shall be NIST Standard Reference Materials (SRMs) or vendor certified materials traceable to these standards.
- Calibration records shall be maintained for each piece of equipment that requires calibration.
- All calibrations shall be preserved on electronic media.

The calibration requirements and respective corrective action shall be accessible, either in the laboratory SOPs or the QAM, for each instrument or analytical method in use.

3.8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

3.8.1 Field Activities

ERM and subcontractors that are providing services shall comply with this QAPP and the FSP for performance of the OU3 RI/FS. These documents shall provide information on the inspection and acceptance criteria for job specific supplies and consumables. Laboratory consumables, such as sample containers and associated preservatives, will be inspected and distributed by the laboratory, and will be identifiable by date received, date opened, and date expired, where applicable. Summa canisters will have laboratory-assigned unique numbers for traceability. ERM personnel will document the containers and preservatives on the chain-of-custody form. Prior to being used at OU3, all other supplies will be inspected by the ERM Field Manager.

3.8.2 Laboratory Activities

The laboratory QA Officer, or designee, shall be responsible for the oversight of standards traceability and holding time compliance. All standards must be traceable either to a NIST, ASTM, or USEPA primary reference standard. Certification records of all standards received shall be retained.

Standards and QC materials must be labeled with expiration dates. The standard materials shall not exceed the manufacturer's expiration date. Expiration dates for laboratory prepared stock solutions or diluted standards shall be no later than the expiration date of the stock solution or material. Expiration dates for reagents shall be documented based on chemical stability, possibility of contamination, and environmental storage conditions.

A second source reference standard is a standard purchased from a different vendor than the vendor supplying the primary source standard, or a different lot from the same vendor, and is used to independently confirm an initial calibration. Newly prepared standard solutions are to be verified prior to use against a known standard from another source. Preparation and handling of calibration standards are addressed in the laboratory SOPs and in the laboratory QAM.

3.9 DATA ACQUISITION REQUIREMENTS

Non-direct measurements may be used to gather data. Examples of these include: literature searches, database query, and retrieval. In these measurements, only reliable, documented sources shall be used, and a reference of this source document shall be cited in all data summaries and reports. Any relevant verification from multiple, independent sources that yield comparable data will be documented.

3.10 DATA MANAGEMENT

The analytical, survey and geological electronic and hardcopy data will be managed and maintained by ERM. Any requests for these data by third parties must be first approved by the Working Group and subsequently communicated by the Working Group to ERM. Data management for the project has the following objectives:

- Establish a controlled, functional, and efficiently operated data management system and accompanying procedures to manage, analyze, document, and transfer the environmental data that are collected and generated.
- Maintain a usable and accurate database throughout the life of the project.
- Process specific data requests from the Working Group and ERM project personnel.
- Transfer specific data components to other parties, as appropriate.
- Archive the database and related documentation upon closure of the project.

The data, at a minimum, will meet the requirements of the ADEQ *Groundwater Data Submittal Guidance Document* (Version 3.3); however, this document does not address all data needs of the OU3 RI/FS. Additional data fields may be added to accommodate the requirements of the project. All changes and additions must be reviewed and approved by the ERM PM and/or ERM QA/QCM. Laboratory data management is discussed in the laboratory QAM.

3.10.1 Data Transmittal, Transformation, and Analysis

Tables containing analytical data will be generated from the laboratories electronic or hardcopy deliverable. GIS data may be used to generate boring logs, groundwater flow maps, and vertical and lateral isoconcentration plots.

Geologic data obtained from boring logs, well construction information, survey coordinates and elevations may be entered into tables and figures from original field forms. These data will be reviewed by the ERM PM to ensure that the lithologic descriptions are consistent and utilize the same terminology throughout the field and data entry processes. After import, the data will be reviewed for accuracy and completeness.

3.10.2 Data Storage and Retrieval

All electronic data will reside in ERM's OU3 RI/FS database to be accessed and managed by a Database Manager. All records will be maintained by ERM until project completion and closeout. As necessary, records may be transferred to an off-site storage facility and retrieved upon request.

4.0 ASSESSMENT/OVERSIGHT

4.1 PURPOSE AND BACKGROUND

The assessment oversight of the project activities shall also include a process of review and evaluation through field QA/QC forms, the issuance of NCRs and subsequent corrective actions, internal peer review, and laboratory oversight. This process will ensure that this QAPP is adhered to, the quality of the data is adequate, and corrective actions, when needed, are implemented effectively and in a timely manner. Nonstatistical assessment of the data usability will be achieved by using professional judgment and through knowledge of the site.

4.1.1 Assessment Activities and Project Planning

Implementation of the assessment and project planning activities is initiated by the ERM PM on behalf of the OU3 Working Group. Personnel on the Management Team are actively involved in the implementation and/or the assessment stages. The approximate schedule of activities is identified in the FSP, or by the judgment of the ERM PM and Lead Technical Support (LTS). Unanticipated events require the notification and/or involvement of the OU3 Working Group. The OU3 Working Group must then notify the USEPA of these events. Work on specific phases of each project is not initiated or considered complete until verified by the ERM PM.

The PM is primarily responsible for completion of field records and review of the information. The PM will be responsible for ensuring that no additional work that is dependent on a nonconforming activity is performed until the corrective action(s) is completed. Reviews of field QA/QC forms will be documented to ensure compliance with the sampling and analytical directives of this QAPP and the FSP. These reviews will be performed by the ERM QA/QCM, or designee, and will verify that sampling activities are performed in accordance with the procedures established.

The OU3 RI/FS QAPP contains guidance that discusses the processes of sample collection and handling, field measurement collection, collection of media for laboratory analysis, decontamination of equipment, transport of samples to the laboratory, and proper custody documentation.

Deviations from these procedures are to be noted on field documentation records such as the field logs, Sample Collection Log, Groundwater Sample Collection Log, Daily Sample Checklist, and the chain-of-custody form. If such deviations are expected to influence the project data, they will be brought to the attention of the ERM PM and/or the LTS. The ERM PM will then contact the OU3 Working Group who will contact the USEPA with suggested corrective actions. Resolutions might include re-sampling of the affected samples and postponing further work dependent on the nonconforming activity until corrective actions are completed.

Review of field measurements will be performed by the PM or designee. The following items will be addressed to ensure that they are complete and accurate during the review process:

- Field Log information;
- Groundwater Sample Collection Log;
- Soil Sample Collection Log;
- Soil Vapor Sample Collection Log;
- Soil Vapor Monitoring Well Sample Collection Log;
- Daily Sample Checklist;
- Chain-of-Custody Form;
- Sampling methodology;
- Instrument selection and use including calibration and standardization;
- Field deviations; and
- Sampling limitations.

The ERM PM will determine if all components of a given phase of the project are ready for the commencement of work.

Any project team member may initiate the field corrective action process. This process consists of identifying a problem, acting to eliminate the problem, documenting the corrective action, monitoring the effectiveness of the corrective action, and verifying that the problem has been eliminated. Although not all inclusive, examples of corrective actions for field measurements may include the following:

- Repetition of a measurement to check the error;

- Check for all proper adjustments for ambient conditions such as temperature;
- Check of batteries;
- Calibration checks;
- Recalibration;
- Replace instruments or measurement devices;
- Stop work (if necessary);
- Revisions to information submitted on chain-of-custody forms; and
- Amendment of sampling procedures or Work Plans.

Technical staff and project personnel will be responsible for reporting all technical or QA nonconformance or suspected deficiencies of any activity or issued document by reporting the situation to the ERM PM and the QA Coordinator on a Nonconformance Report. The QA Coordinator will be responsible for assessing the suspected difficulty in consultation with the LTS or QA/QCM on making a decision based on the potential for the situation to impact the quality of the data. A corrective action decision, if necessary, will be determined by the ERM PM and implemented by the PM. The PM has the authority to initiate stop work orders, if necessary, and is responsible for ensuring that a corrective action for a nonconformance is initiated, which can include the following actions:

- Evaluating all reported nonconformance;
- Determining disposition or action to be taken;
- Maintaining a log of nonconformance;
- Reviewing nonconformance reports and corrective actions taken; and
- Ensuring that nonconformance reports are included in the final site project files.

The PM is primarily responsible for completion of field records and review of the information after being transcribed to electronic data. If appropriate, the PM will be responsible for ensuring that no additional work that is dependent on the nonconforming activity is performed until the corrective action(s) is completed.

4.1.2 *Assessment of Project Activities*

Surveillance of the project activities shall be an ongoing process from data acquisition to data reduction and reporting. The sampling design and/or analytical program will be periodically evaluated to determine if the project study objectives and completeness goals are being satisfied. To achieve the data quality objectives and completeness goal, modifications in sampling techniques, frequency and/or design, analytical methods, or target analyte lists may be recommended to the USEPA. These evaluations will be performed by the QA Coordinator. All reports shall undergo a peer review by members of the OU3 Working Group prior to submittal to the USEPA.

4.2 *LABORATORY DATA*

Prior to submitting analytical data to ERM, the laboratory must verify compliance to the method requirements. The laboratory will follow their QAM, SOPs, and this QAPP for all sample analyses. The laboratory will also be responsible for the oversight of the data quality for all analyses. Any sample integrity issues, discrepancies with the chain-of-custody, or concerns with the analysis will be addressed and resolved through the laboratory QA Officer.

All analytical data shall be reviewed by the laboratory and shall include a minimum of two levels of documented review. The Level 3 review is performed by the laboratory on a percentage of data to ensure system compliance and may or may not include data from OU3. For each level, the review process shall be documented, signed, and dated by the reviewer. Each step of this review process shall include the evaluation of data quality based on both the results of the QC data and the professional judgment of those conducting the review.

4.2.1 *Level 1 Analyst Review*

The Level 1 analyst review shall include QC review, method compliance, and documentation accuracy. For data that are manually processed, all steps in the computation shall be provided including equations used and the source of input parameters such as response factors, dilution factors, and calibration constants, and shall be initialed and dated by the analyst and attached to the data sheets. For data entered into the computer, the analyst shall verify the sample specific and project specific information (i.e., project numbers, sample numbers, units, and dilution factors).

4.2.2 Level 2 Peer Review

The Level 2 peer review shall be performed by a supervisor, another analyst, or data review specialist. The function of this review is to provide an independent, complete peer review of the analytical data. This review shall include the review of QC performance, method compliance, documentation, calibrations, and identifications.

4.2.3 Level 3 Peer Review

The Level 3 peer review is performed by the laboratory PM, QA Officer, or designee. This review shall provide a total overview of the data package to ensure its compliance with project requirements. All errors and nonconformance noted shall be corrected and/or documented.

4.2.4 QA Coordinator Review

Randomly selected data packages shall be reviewed by the laboratory PM, QA Coordinator, or designee. Every hardcopy data deliverable shall be reviewed by the laboratory PM, or designate, to ensure data validity and accuracy. The QA Coordinator is the primary person responsible for the enforcement and oversight of the QA program.

NCRs will be required for any errors noted. In all cases, an NCR shall be issued with the name of the individual reporting the issue, a description of the noncompliance issue, the corrective action taken, the date the issue was discovered, and the affected project samples. All employees are responsible for reporting the nonconformance. The appropriate supervisor is responsible for assuring that the corrective actions are taken.

4.3 SYSTEM AND PERFORMANCE AUDITS

System audits and performance audits of field and laboratory activities may be performed to ensure compliance with the sampling and analytical directives. These audits will verify that sampling and analysis activities are performed in accordance with the established procedures. The QA Coordinator will be responsible for these audits.

4.3.1 Field Audits

Field audits shall be performed by ERM field staff on a daily basis by a cross-checking the field logs, the Sample Collection Logs, the chain-of-

custody forms, and the sample containers. Daily cross-checking confirms sample identity, sample integrity, and sampling procedures and will be completed by the sampler prior to shipping the samples. Additionally, the field logs and the chain-of-custody form will be provided to the ERM QA/QCM or PM by facsimile or e-mail for additional verification.

4.3.2 *Laboratory Audits*

Laboratory performance and system audits are addressed in the laboratory QAM. The audit shall consist of a general audit and specific procedure audit. A general audit shall be an overview of the whole laboratory from sample receipt to sample disposal for compliance with the QAM. A specific technical audit shall be a detailed in-depth review of an actual method or procedure.

After the general and/or specific audits have been conducted, the laboratory QA Manager shall complete a laboratory audit record form. Any issues, observations, and findings shall be discussed with the laboratory Manager. The laboratory Manager, laboratory QA Manager, and other laboratory staff, as necessary, shall suggest and implement corrective actions. The results of the audit shall be kept on file along with any corrective action taken. If, as a result of the audit, there is uncertainty as to the validity or correctness of a test result, immediate corrective action should be taken and the client notified in writing.

ERM will not perform any laboratory audits and will, instead, rely upon audits performed by state agencies or other certifying authorities to establish system compliance. Laboratory audits performed by various state agencies, such as ADHS, are addressed in the laboratory QAM. The laboratory will provide ERM with the findings from the most recent audit and any corrective actions associated with the audit. ERM will evaluate the results of the most recent two sets of PE samples analyzed by the laboratory for state certification programs.

4.3.3 *Reports to Management*

QA reports to management include verbal status reports, and written reports on field sampling activities, laboratory processes, data validation reports, and final project reports. These reports shall be the responsibility of the QA Coordinator. Reports will be reviewed by the ERM PM and reviewed by the ERM management team reviewer prior to submittal to the OU3 Working Group. Prior to USEPA submittal, draft reports will be evaluated by the OU3 Working Group.

5.0 DATA REVIEW, VALIDATION, AND VERIFICATION

5.1 PURPOSE/BACKGROUND

The data validation process will evaluate the analytical data for method QC and laboratory QC compliance, and will determine the validity and applicability of the data. Data validation will be performed by an outside contractor, Laboratory Data Consultants, Inc., of Carlsbad, California. Based on the findings of the validation process, data validation qualifiers (Table 8) which explain the rationale for applying a particular validation qualifier may be assigned. The validated project data, including qualifiers and reason codes, will be entered into the OU3 database, thus enabling this information to be retained or retrieved, as needed. A summary of the data qualifiers shall be written for each sampling activity and shall be included in the report to the Working Group.

5.2 VALIDATION METHODS

The analytical data will be validated using guidance suggested by the following documents:

- *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (USEPA 1999b);
- *Advisory–Active Soil Gas Investigations* (CRWQCB 2003);
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* (USEPA 1999a);
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (USEPA SW 846 Third Edition 1993); and
- *Region 9 Superfund Data Evaluation/Validation Guidance* (USEPA 2001c).

These guidance documents will be used in conjunction with the laboratory SOPs for the respective analytical methods. Professional judgment will be exercised throughout the validation effort, particularly for situations that are not addressed or clearly specified in the SOPs or in the guidance documents.

USEPA Region 9 guidance describes four evaluation tiers that can be used for validation of laboratory data. These tiers are described below.

Evaluation Tiers for Validation

Tier	Work Product/Goal	Examples of Use
1A	Quick summary of key analytical issues and deficiencies regarding analytical data quality. Is used when extensive data review is not required for project objectives.	Regularly occurring monitoring projects with a large amount of historical data. Samples may be taken several times annually. Decision process does not rely exclusively on data analysis.
1B	Summary that determines whether contract-required quality control specifications have been met.	Regularly occurring monitoring projects with a large amount of analytical data. Often used by USEPA to evaluate data quality when USEPA is not the lead agency on the project.
2	Data review report based on specific data quality criteria. This tier is only used when Tier 1A or 1B is not sufficient for project objectives.	Site assessment investigation that does not require further USEPA involvement or a Brownfield site investigation that does not require additional remedial action.
3	Detailed data validation report based on project-specific data quality control specified in a QAPP.	An investigation that USEPA leads or a site under USEPA enforcement authority.

Source: USEPA, 2001. *Region 9 Superfund Data Evaluation/Validation Guidance, R9QA/006.1*

For this investigation, a combination of Tier 1A and Tier 3 validation was selected since it is under USEPA enforcement authority and there is a long history of data collection. Tier 3 data validation will be performed on 10 percent of the groundwater and soil vapor samples collected under this QAPP. This definitive validation will be used to determine data quality and identify any nonconformance in field or laboratory activities.

Raw data will be reviewed for a subset of the samples including all those used to define the boundaries of soil vapor impacts. All data will minimally be evaluated according to Tier 1A or Tier 3 data validation protocols. At any time, further validation can be performed to establish QA/QC compliance. Summaries of the data validation and flagging criteria are presented in Tables 9, 10, and 11 for groundwater by SW-846 Method 8260B, soil vapor from monitoring wells by USEPA Method TO-15, and groundwater by SW-846 Method 8270C, respectively.

The laboratory will supply a data deliverable that supports sufficient traceability and QC for legally defensible data. This data package will

include all relevant QC sample data, calibration data, method QC data, laboratory case narratives, custody information, standards traceability data, and any information pertaining to the sample analysis excluding raw instrument data, unless equivalent information is not available in summary form. The analytical data package requirements checklist is located in Section 2.9. Inconsistencies or errors contained in the data package will be noted by the ERM QA/QCM and discussed with the laboratory PM. The laboratory PM is responsible for resolving any inconsistencies or errors in a timely manner.

5.3 COMPLETENESS CHECK

Data will be verified for completeness against the chain-of-custody forms to ensure that the analyses requested were performed and reported. The percentage of usable data shall also be determined by comparing the total number of data planned against the number of usable data. This number shall be reported in the RI Report. Compilation of sufficient data is necessary for meeting the project data quality objectives.

5.4 VERIFICATION OF FIELD DATA

As discussed in Section 4.3.1, field data shall be checked in the field prior to submittal of the samples to the laboratory. This review is designed to identify field documentation errors prior to sample submittal. Field measurement data will also be verified using procedures that include meter calibration checks, routine checks during the recording and processing of data, e.g., looking for errors in identification codes, and looking for outliers that may be the result of transcription errors or field instrumentation breakdown. Obvious mistakes in identifiers or field data will be corrected when possible. Since outliers may indicate a greater degree of spatial or temporal variability than expected rather than an error, results will be reviewed carefully before a decision to include or exclude a suspect field measurement is made.

5.5 RECONCILIATION WITH SCOPE OF WORK

The final data validation activity is to determine whether the data meet the planned SOW. The Data Coordinator shall review the data within the context of existing site knowledge. The decision whether validated data are sufficient (that any gaps and uncertainties identified in the validation

process are within the bounds of the program needs) rests with the Working Group in conjunction with the ERM PIC and PM who will direct subsequent actions at OU3. These decisions should be made only after careful review of the data validation report and recommendations on usability provided. Data usability may be determined on a sample-specific basis or on a sample set basis, as needed, depending on the decisions or actions for which the sampling and analytical program was designed.

6.0 REFERENCES

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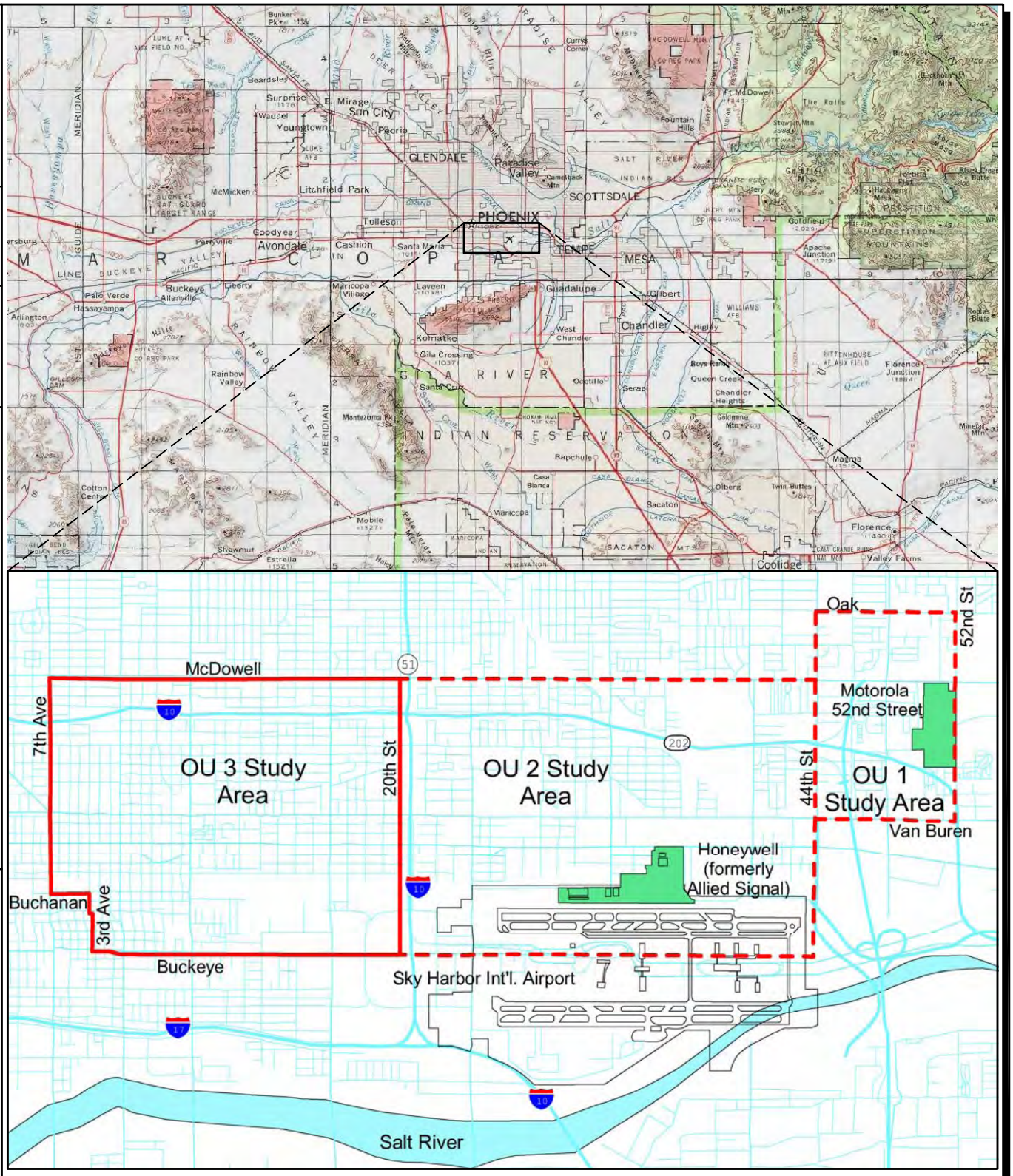
USEPA. 2009. *Administrative Settlement Agreement and Order on Consent for Remedial Investigation and Feasibility Study. Motorola 52nd Street Superfund Site Operable Unit 3*. USEPA Region IX Docket No. 2008-17. 22 September.

USEPA. 2010. *EPA Region 9's Suggested Framework for Investigating and Evaluating Vapor Intrusion to Indoor Air of Residential or Industrial Buildings Motorola 52nd Street Superfund Site*. January.

Figures

Project No. 0096498.01
Date: 05/19/09
Drawn By: R. Olson
CAD File: G:\0096498\01\009649801-05.dwg



LEGEND

OU3 Study Area Boundary

OU1 and OU2 Study Area Boundary

References:
TOPO!® Software
U.S.G.S. 500k Map Series; Phoenix, Arizona
Shaw Environmental, 04/19/04.

Figure 1
Site Location Map
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

ERM 05/09

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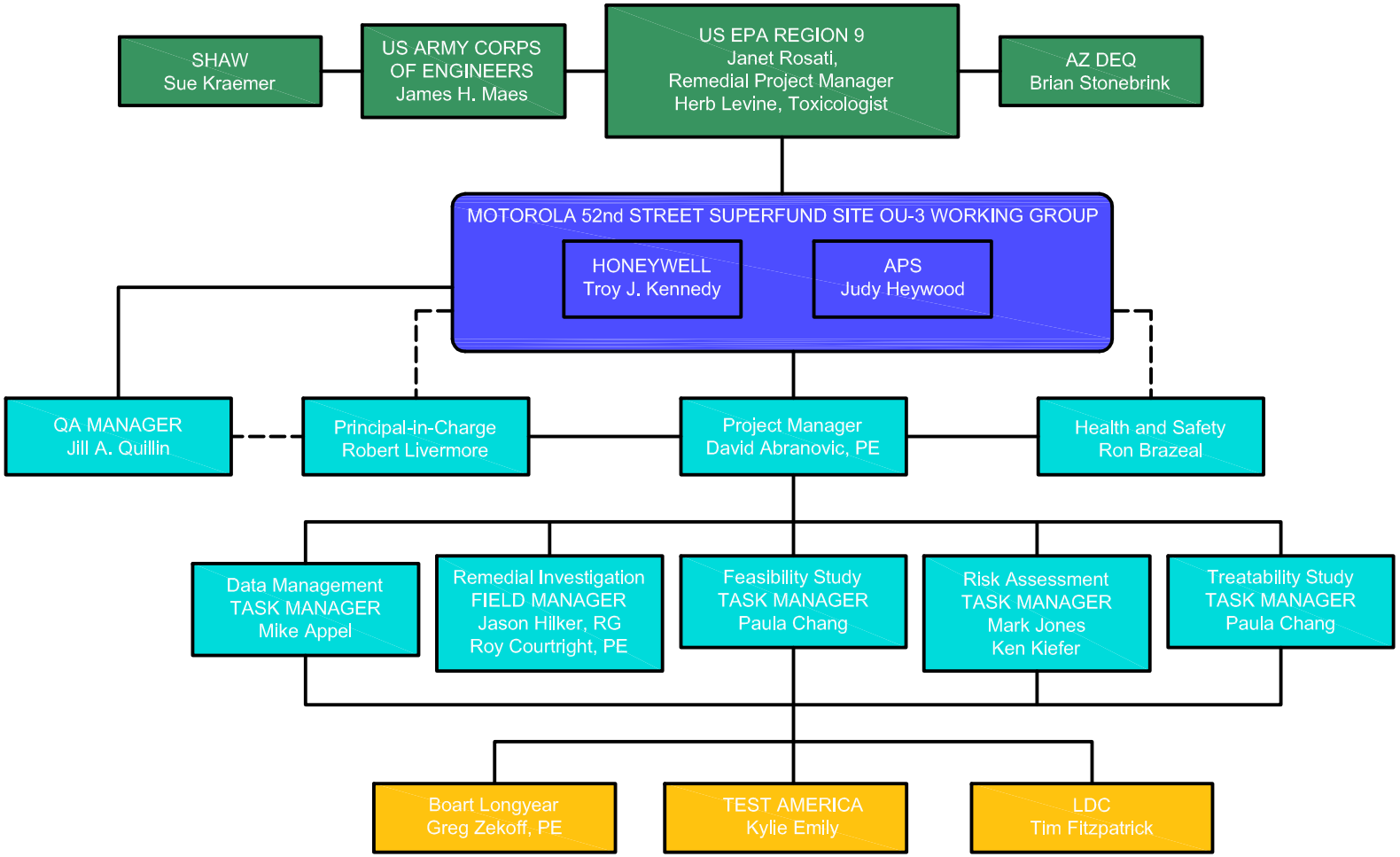

Figure 2

Project Organization Chart
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

ERM *08/10*

Tables

TABLE-1

52nd Street Superfund Site Operable Unit 3 Study Area
Method Control Limits for Groundwater Quality Control Samples

			Laboratory Control Samples		Matrix Spike Samples	
			%R	RPD	%R	RPD
Method	**Analyte**	**CAS Number**	**Water**	**Water**	**Water**	**Water**
Volatiles	1,1,1-Trichloroethane	71-55-6	75 - 125	15	70 - 130	25
	1,1,2,2-Tetrachloroethane	79-34-5	80 - 120	20	70 - 125	25
	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	60 - 140	15	65 - 140	20
	1,1,2-Trichloroethane	79-00-5	80 - 120	15	75 - 125	20
	1,1-Dichloroethane	75-34-3	70 - 125	15	70 - 130	20
	1,1-Dichloroethene	75-35-4	75 - 125	20	70 - 130	25
	1,2-Dichloroethane	107-06-2	75 - 130	15	65 - 140	20
	Acetone	67-64-1	10 - 150	35	10 - 150	35
	Bromochloromethane	74-97-5	80 - 125	15	75 - 130	20
	Bromodichloromethane	75-27-4	80 - 120	15	75 - 125	20
	Bromoform	75-25-2	75 - 130	20	65 - 125	25
	Chlorodibromomethane	124-48-1	80 - 120	15	70 - 130	20
	Chloroform	67-66-3	75 - 120	15	70 - 130	15
	Chloromethane	74-87-3	60 -140	20	55 - 145	35
	cis-1,2-Dichloroethene	156-59-2	80 - 120	15	70 - 125	20
	Dibromomethane	74-95-3	75 - 120	15	70 - 120	20
	Dichlorodifluoromethane	75-71-8	60 - 150	30	60 - 150	30
	Methyl ethyl ketone	78-93-3	40 - 150	35	15 - 150	30
	Tetrachloroethene	127-18-4	70 - 130	20	65 - 130	25
	Trichloroethene	79-01-6	65 - 150	25	70 - 125	25
	trans-1,2-Dichloroethene	156-60-5	80 - 120	15	75 - 125	25
	Trichlorofluoromethane	75-69-4	70 - 150	25	65 - 150	25
	Vinyl Chloride	75-01-4	70 - 130	20	60 - 140	25
Semivolatiles	1,4-Dioxane	123-91-1	80 - 120	25	70 - 130	25
Volatile Surrogates	Toluene -d8		80 - 120			
	4-Bromofluorobenzene		80 - 125			
	Dibromfluoromethane		80 - 130			
Internal Standards	Bromochloroethane		-50%- +200%			
	1,4-Difluorobenzene		-50%- +200%			
	Chlorobenzene -d5		-50%- +200%			
Semivolatile- 1,4-Dioxane Surrogate	Nitrobenzene-d5		38 - 125		59 - 120	
	1,4-Dioxane-d8		32 - 57		36 - 81	

TABLE-2

52nd Street Superfund Site Operable Unit 3 Study Area
Method Control Limits for Soil Vapor Quality Control Samples

		Laboratory Control Samples	
		%R	RPD
Analyte	**CAS Number**	**Water**	**Water**
1,4-Dichlorobenzene	106-46-7	65 - 135	25
1,1,1-Trichloroethane	71-56-6	65 - 135	25
Bromomethane	74-83-9	65 - 135	25
Bromoform	75-25-2	65 - 135	25
Bromoethene (Vinyl Bromide)	593-60-2	65 - 135	25
Bromodichloromethane	75-27-4	65 - 135	25
Benzyl Chloride	100-44-7	65 - 135	25
Benzene	71-43-2	65 - 135	25
Allyl Chloride	107-05-1	65 - 135	25
Acetone	67-64-1	65 - 135	25
4-Methyl-2-pentanone (MIBK)	108-10-1	65 - 135	25
4-Ethyltoluene	622-96-8	65 - 135	25
2-Propanol	67-63-0	65 - 135	25
2-Hexanone	591-78-6	65 - 135	25
Carbon tetrachloride	56-23-5	65 - 135	25
1,2-Dichlorobenzene	95-50-1	65 - 135	25
1,1,2,2-Tetrachloroethane	79-34-5	65 - 135	25
1,1,2-Trichloroethane	79-00-5	65 - 135	25
1,1-Dichloroethane	75-34-3	65 - 135	25
1,1-Dichloroethene	75-35-4	65 - 135	25
1,2,4-Trichlorobenzene	120-82-1	65 - 135	25
2-Butanone (MEK)	78-93-3	65 - 135	25
1,2-Dibromoethane (EDB)	106-93-4	65 - 135	25
2,2,4-Trimethylpentane	580-84-1	65 - 135	25
1,2-Dichloroethane	75-34-3	65 - 135	25
1,2-Dichloropropane	78-87-5	65 - 135	25
1,3,5-Trimethylbenzene	108-67-8	65 - 135	25
1,3-Butadiene	106-99-0	65 - 135	25
1,3-Dichlorobenzene	541-73-1	65 - 135	25
Chlorobenzene	108-90-7	65 - 135	25
1,2,4-Trimethylbenzene	95-63-6	65 - 135	25
Tetrahydrofuran	109-99-9	65 - 135	25
Carbon disulfide	75-15-0	65 - 135	25
Methyl-tert-butyl Ether (MTBE)	1634-04-4	65 - 135	25
Methylene Chloride	75-09-2	65 - 135	25
o-Xylene	95-47-6	65 - 135	25
Propene	115-07-1	65 - 135	25

TABLE-2

52nd Street Superfund Site Operable Unit 3 Study Area
Method Control Limits for Soil Vapor Quality Control Samples

		Laboratory Control Samples	
		%R	RPD
Analyte	**CAS Number**	**Water**	**Water**
Hexane	110-54-3	65 - 135	25
Tetrachloroethene	127-18-4	65 - 135	25
Hexachlorobutadiene	87-68-3	65 - 135	25
Toluene	108-88-3	65 - 135	25
trans-1,2-Dichloroethene	156-60-5	65 - 135	25
trans-1,3-Dichloropropene	10061-02-6	65 - 135	25
Trichloroethene	79-01-6	65 - 135	25
Trichlorofluoromethane	75-69-4	65 - 135	25
Vinyl Acetate	108-05-4	65 - 135	25

TABLE-3

52nd Street Superfund Site Operable Unit 3 Study Area

Summary of Laboratory Calibration, Internal Quality Control Procedures, Acceptance Criteria, and Corrective Actions

Analysis Method	Calibration/ Method QC	Frequency	Acceptance Criteria	Corrective Action
VOCs TO-15	BFB Tune	Every 24 hours	Refer to Method TO-15	Retune or service mass spectrometer. Repeat BFB analysis.
	Initial Calibration	Initially and as required - 5-point minimum	RSD <30% r2>0.990 for targets	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	At beginning of each 12 hour shift	The % RSD of the response factor for each target analyte in the CCV must be ± 30% from the average response factor of the initial calibration curve, or if linear calibration is used, the concentration must be ± 30%.	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Internal Standards	Added to every project and QC sample	RRT within 0.3 minutes of the mid-point CCAL standard. Response is ± 40% of the mid-point CCAL standard.	Rerun to confirm matrix effect. Dilute Sample. Flag data if matrix effect is confirmed.
	Surrogates	Added to every project and QC sample	Recovery of 70-130%	If surrogate is outside control limits, sample will be reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	Recovery of 65-135% for target analytes	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
VOCs 5030B/8260B	BFB Tune	Every 12 hours	Refer to Method 8260B	Retune or service mass spectrometer. Repeat BFB analysis.
	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% RRF > 0.05 r2>0.99 for targets	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	At beginning of each 12 hour shift	%D < or =20%, The minimum relative response factors for the System Performance Check Compounds are listed as: chloromethane 0.10, 1,1-dichloroethane 0.10, bromoform 0.10, chlorobenzene 0.30, and 1,1,2,2-tetrachloroethane 0.30. Non-SPCC and CCC analytes must be recovered within 20% until in-house limits are established	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Internal Standards	Added to every project and QC sample	RRT within 0.5 minutes of the mid-point CCAL standard. Response is -50-100% of the mid-point CCAL standard.	Rerun to confirm matrix effect. Dilute Sample. Flag data if matrix effect is confirmed.
	Surrogates	Added to every project and QC sample	QAPP specific. Refer to Table 1	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	QAPP specific. Refer to Table 1	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	QAPP specific. Refer to Table 1	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.

TABLE-3

52nd Street Superfund Site Operable Unit 3 Study Area

Summary of Laboratory Calibration, Internal Quality Control Procedures, Acceptance Criteria, and Corrective Actions

Analysis Method	Calibration/ Method QC	Frequency	Acceptance Criteria	Corrective Action
1,4-Dioxane	Tune Evaluation (DFTPP)	Beginning, every 12 hours of analysis	Must pass Table 1 criteria	Re-inject Re-tune Perform maintenance
	Column Performance	Beginning, every 12 hours of analysis	Must pass Tailing Factor Benzidene ≤ 3.0	Perform maintenance
	5 Point Calibration Curve*(min.)	Whenever calibarion check is out of criteria	CCC - 1,4 DCB %RSD ≤ 30 SPCC - N-Nitroso-di-n-propylamine RF 0.05 >15% RSD use curve ζ ≥ 0.990	Re-inject curve Prepare new standards Perform maintenance
	Initial Calibration Verification (ICV, Second Source)	Every new calibration curve	%D ≤ 30	Re-inject curve Prepare new standards Perform maintenance Run new curve
	Continuing Calibration Verification (CCV)	Beginning, every 12 hours	CCC & taget %D ≤ 20 SPCC RF 0.05 *RT ± 0.05m *Area -50% to +100% *vs IS in mid-level I. Cal.	Re-inject curve Prepare new standards Perform maintenance Run new curve
	Method Blank	Every batch up to 20 samples	< RL	Re-inject batch Fill our IRCI Re-extract batch
	LCS/LCSD	Every batch up to 20 samples	Default Limits: 80-120% and ≤ 25 RPD	Re-extract batch
	MS/MSD	Every batch up to 20 samples	Default Limits: 70-130% and £ 25 RPD	If LCS/LCSD is within limits, flag data as "suspected/matrix interference" If LCS/LCSD is not within limits, re-extract batch
	Surrogates, Nitrobenzene-d5 & 1,4-Dioxane-d8	Each sample	Within historical limits**	Re-inject Re-extract Fill our CAR or flag data
	Internal Standard, 1,4-DCB-d4	Each sample	IS* RT + 0.50m IS* Area -50% to 100% *vs IS in CCV	Re-inject If blank is acceptable, flag data as "suspected/matrix interference"

Notes:

*Method 8000C, Procedure Section 11.5 allows for non-linear calibration, requiring six standards. The coefficient of the determination must be > 0.99, and is an acceptable calibration technique.

**For historical limits, refer to the Control Charting Module in the LIMS database.

DRO/ORO by 8015 AZR1	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% r2>0.995	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	Every 10 samples and at the end of each run	Primary Source CCV: 70-130% Secondary Source Immediately after calibration: 80-120%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Surrogates	Added to every project and QC sample	70-130%	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	70-130%	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	Laboratory determined control limits	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
GRO & DRO/ORO by 8015D	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% r>0.99	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	Every 10 samples and at the end of each run	85-115%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Surrogates	Added to every project and QC sample	Laboratory determined control limits	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	Laboratory determined control limits	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	Laboratory determined control limits	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.

TABLE-3

52nd Street Superfund Site Operable Unit 3 Study Area

Summary of Laboratory Calibration, Internal Quality Control Procedures, Acceptance Criteria, and Corrective Actions

Analysis Method	Calibration/ Method QC	Frequency	Acceptance Criteria	Corrective Action
PAHs By 8310	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% r>0.99	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	Every 10 samples and at the end of each run	80-120%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Surrogates	Added to every project and QC sample	Laboratory determined control limits	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	Laboratory determined control limits	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	Laboratory determined control limits	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
ICP Metals - 6010B	Initial Calibration	Each analytical day - 3-point minimum	r2>0.995	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Initial Calibration Verification	Immediately following the calibration	90-110% RSD < 3%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Continuing Calibration	Every 10 samples and at the end of each run	90-110%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	ICSA / ICSAB	After each calibration and every eight hours	80-120%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	85-115% Recovery, RPD <20%	Redigest and re-analyze samples
	MS/MSD	5% frequency for project samples	80-120% Recovery, RPD <20%	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
Hg by 7470	Initial Calibration	Each analytical day - 5-point minimum	r2>0.995	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Initial Calibration Verification	Immediately following the calibration	90-110%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Continuing Calibration	Every 10 samples and at the end of each run	90-110%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	85-115% Recovery, RPD <20%	Redigest and re-analyze samples
	MS/MSD	5% frequency for project samples	85-115% Recovery, RPD <20%	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
Chrom VI By SM3500-Cr D	Initial Calibration	Quaterly, As Needed,	r2>0.995	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Initial Calibration Verification Continuing Calibration	Immediately following the calibration	90-110%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	90-110% Recovery, RPD <20%	Re-analyze the LCS/LCSD. Redigest and re-analyze the samples.
	MS/MSD	5% frequency for project samples	80-120% Recovery, RPD <20%	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.

TABLE-3

52nd Street Superfund Site Operable Unit 3 Study Area
Summary of Laboratory Calibration, Internal Quality Control Procedures, Acceptance Criteria, and Corrective Actions

Analysis Method	Calibration/ Method QC	Frequency	Acceptance Criteria	Corrective Action
Cyanide By 9014	Initial Calibration	Quaterly, As Needed,	r2>0.990	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Initial Calibration Verification Continuing Calibration	Immediately following the calibration	90-110%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	90-110% Recovery, RPD <20%	Re-analyze the LCS/LCSD. Redigest and re-analyze the samples.
	MS/MSD	5% frequency for project samples	80-120% Recovery, RPD <20%	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
PCBs By 8082	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% r>0.99	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration - Arochlor 1016 & 1260 routinely analyzed. Other Arochlors are analyzed when pattern matches are indicated	Every 10 samples and at the end of each run	80-120%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Surrogates	Added to every project and QC sample	Laboratory determined control limits	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	Laboratory determined control limits	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	Laboratory determined control limits	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.
Pesticides by 8081	Initial Calibration	Initially and as required - 5-point minimum	RSD <20% r>0.99	Service instrument. Re-run failing level if extraneous causes are suspected. Reprep Standards. Recalibrate.
	Continuing Calibration	Every 10 samples and at the end of each run	80-120%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Breakdown (Endrin and DDT)	Beginning of the analytical sequence	Breakdown < 15%	Sevice instrument. Re-run. Repeated failure requires recalibration.
	Surrogates	Added to every project and QC sample	Laboratory determined control limits	If surrogate is outside control limits, sample will be reprepped and/or reanalyzed. If reanalysis confirms original analysis, flag data. Examine batch QC.
	Method Blank / Instrument Blank	One per analytical batch or 5% frequency, whichever is more frequent.	Less than the reporting limit.	Identify source of contamination. Reprep and/or reanalyze samples.
	LCS/LCSD	One per analytical batch or 5% frequency, whichever is more frequent.	Laboratory determined control limits	If either LCS/LCSD is out and surrogates are acceptable, flag data. Rerun LCS/LCSD if extraneous causes are expected. If LCS/LCSD is OK but RPD is out, flag data. If both LCS/LCSD are out, reprep samples if possible & rerun. samples. Flag data if results are consistent with original data.
	MS/MSD	5% frequency for project samples	Laboratory determined control limits	Examine unspiked sample. Check LCS of batch. Evaluate for matrix effects and flag data as necessary.

TABLE-4

52nd Street Superfund Site Operable Unit 3 Study Area
Contaminants of Concern (COCs) Site Characterization Screening Levels and Remedial Action Levels in Groundwater and Soil Vapor

	Groundwater (µg/L)		*Soil Vapor (µg/L)*	
	Direct Contact Exposure Pathway		*Shallow Soil Gas*	
Chemical Name	*EPA RSL[1] (Tap Water)*	*EPA MCL[2]/ ADEQ AWQS[3]*	*Residential MHHSL[5]*	*Commercial/ Industrial MHHSL[5]*
1,1,1-Trichloroethane (1,1,1-TCA)	9,100	200	2,300	18,000
1,1-Dichloroethane (1,1-DCA)	2.4	NE	0.65	6.4
1,1-Dichloroethene (1,1-DCE)	340	7	91	730
cis-1,2-Dichloroethene (cis-1,2-DCE)	370	70	27	220
Chloroethane (CE, Ethyl chloride)	21,000	NE	NE	NE
Tetrachloroethene (PCE)	0.11	5	0.18	1.8
Trichloroethene (TCE)	1.7	5	0.52	5.1
Vinyl Chloride	0.016	2	.07	2.3
1,4-Dioxane	6.1	NE	NA	NA

[1] EPA Region 9 Preliminary Remediation Goals Table dated 10/20/04 was replaced with Regional Screening Levels (RSLs) as of April 2009.
[2]EPA Office of Water, www.epa.gov/safewater/consumer/pdf/mcl/pdf
[3]Arizona Department of Environmental Quality (AZDEQ) Water Quality Database, Water Quality (AWQS) Standards, September 16, 2002.
[4]This compound is included as a Total Trihalomethane (TTHM). The MCL for TTHMs is 80 µg/L (micrograms per liter) after December 31, 2003.
[5]MHHSL – Motorola 52nd Street Modified Human Health Risk Levels (EPA 2010).
NE – Not Established
NA – Not Applicable

TABLE-5

52nd Street Superfund Site Operable Unit 3 Study Area
Groundwater and Soil Vapor Criteria - Screening Against the Reporting Limt

Analyte	*CAS Number*	*EPA RSL Criteria Basis (µg/L)*	*EPA MCL/ADEQ AWQS Criteria Basis (µg/L)*	*Laboratory Reporting Limit (µg/L)*	*Screening*	*Residential MHHSL (µg/L)*	*Commercial/ Industrial MHHSL (µg/L)*	*TO-15 Laboratory Reporting Limit (µg/L)*	*Screening*
Volatiles									
1,1,1-Trichloroethane	71-55-6	9,100	200	0.5	Pass	2,300	18,000	0.00273	Pass
1,1-Dichloroethane	75-34-3	2.4	NE	0.5	Pass	0.65	6.4	0.00202	Pass
1,1-Dichloroethene	75-35-4	340	7	0.5	Pass	91	730	0.00198	Pass
cis-1,2-Dichloroethene	156-59-2	370	70	0.5	Pass	27	220	0.00198	Pass
Chloroethane (Ethyl chloride)	75-00-3	21,000	NE	1.0	Pass	NE	NE	0.00132	Pass
Tetrachloroethene	127-18-4	0.11	5	0.5	Passes MCL	0.18	1.8	0.00339	Pass
Trichloroethene	79-01-6	2	5	0.5	Pass	0.52	5.1	0.00269	Pass
Vinyl Chloride	75-01-4	0.016	2	0.5	Passes MCL	0.07	2.3	0.00128	Pass
1,4 Dioxane	123-91-1	6.1	NE	1.0	Pass	NE	NE	NA	NA

CAS = Chemical Abstracts Service
MHHSL = Motorola 52nd Street Modified Human Health Screening Levels (EPA 2010)
EPA RSL = Environmental Protection Agency Regional Screening Level
EPA MCL = Environmental Protection Agency Maxumim Contaminant Level
ADEQ AWQS = Arizona Department of Environmental Quality Aquifer Water Quality Standard
µg/L = micrograms per liter
NE - not established
NA - not applicable

TABLE-6

52ND Street Superfund Site Operable Unit 3 Study Area
Laboratory Sample Containers, Preservatives, and Holding Times for Potential Site-Wide Analyses

Media	*EPA Test Method*	*Volume and Container Type*	*Preservation*	*Holding Time*
Soil Vapor	TO-15 (used for split samples)	1L, Summa Canister	None	30 days
Groundwater	VOCs 8260B	3 - 40mL, VOA	Hydrochloric Acid, Stored at 4°C±2°C	14 days
	[1]Semi-VOCs 8270C	1L, amber glass	Stored at 4°C±2°C	7 days to extract, 40 days to analyze extract
IDW Characterization Analyses				
Soil	VOCs 8260B	En Core® device	[2]En Core®, frozen	7 days to extract, 14 days to analyze extract
			If not frozen	48 hours for extraction, 14 days to analyze extract
	TPH 8015AZ R.1	6" stainless steel soil sample liner	Stored at 4°C±2°C	14 days
Groundwater	VOCs 8260B	3 - 40mL, VOA	Hydrochloric Acid, Stored at 4°C±2°C	14 days
	TPH 8015 GRO	3 - 40mL, VOA	Hydrochloric Acid, Stored at 4°C±2°C	14 days
	TPH 8015 DRO-ORO	2-1L amber glass	Stored at 4°C±2°C	7 days
	PAHs 8310	2-1L amber glass	Stored at 4°C±2°C	7 days
	[3]Metals 6010B/7470	1L, HDPE	HNO_3, Stored at 4°C±2°C	28 days
	Chromium VI 3500	500mL, HDPE	Stored at 4°C±2°C	24 hours
	Cyanide 9010B	500mL, HDPE	NaOH to pH > 14, Stored at 4°C±2°C	14 days
	PCBs 8082	2-1L amber glass	Stored at 4°C±2°C	7 days to extract, 40 days to analyze extract
	Pesticides 8081A	2-1L amber glass	Stored at 4°C±2°C	7 days to extract, 40 days to analyze extract

NOTES:

[1]Only 1,4-dioxane will be analyzed using Method 8270C
[2] En Core® = Trade name of En Novative Technologies, Inc. see Section 3.2.3 for soil sample collection procedures
[3]Metals = RCRA 8 (As, Ba, Cd, Cr, Pb, Hg, Se, Ag)

VOCs = Volatile Organic Compounds
TPH = Total Petroleum Hydrocarbons
PAHs = Polynuclear Aromatic Hydrocarbons
PCBs = Polychlorinated Biphenyls
HDPE = High Density Polyethylene Bottle
HNO_3= Nitric Acid

TABLE-7

52ND Street Superfund Site Operable Unit 3 Study Area
Extraction and Analytical Procedures

Extraction or Analytical Method	*Application*	*Description*
TO-15	Volatile Organics	Method TO-15 draws air through a sampling train into an evacuated canister. After receipt by the laboratory, a known volume of air is directed through a solid multisorbent concentrator, which removes water vapor. The VOCs are then thermally desorbed, entrained in a gas stream, and carried onto a gas chromatographic column for separation.
SW-846 Method 8260B	Volatile Organics	Method 8260B uses a capillary column GC/mass spectrometry technique. Volatile compounds are introduced into the GC by purge and trap (SW5030B). An inert gas is bubbled through the soil gas samples to transfer the purgeable organic compounds from the liquid to vapor phase.
8270C	Semi-Volatile Organics	Method 8270 can be used to quantitate most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted, without derivatization, as sharp peaks from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone. Such compounds include polynuclear aromatic hydrocarbons, chlorinated hydrocarbons and pesticides, phthalate esters, organophosphate esters, nitrosamines, haloethers,aldehydes, ethers, ketones, anilines, pyridines, quinolines, aromatic nitro compounds, and phenols, including nitrophenols.
5035	Volatile Organics	Method 5035 uses a purge-and-trap method for gas chromatograph analysis. The vial containing the sample is heated to 40°C and the volatiles purged into an appropriate trap using an inert gas combined with agitation of the sample. Purged components travel via a transfer line to a trap. When purging is complete, the trap is heated and backflushed with helium to desorb the trapped sample components into a gas chromatograph for analysis by an appropriate determinative method.
SW5030B	Volatile Organics	Method 5030B is a procedure for sample preparation and extraction for the analysis of VOCs. The method is applicable to nearly all types of samples. The success of this method depends on the level of interferences in the sample. Results may vary due to the large variability and complexity of matrices of solid waste samples.
8015 GRO	Total Petroleum Hydrocarbons	Method 8015 GRO is used to determine the concentration of various halogenated and non-halogenated aromatic and volatile hydrocarbons by gas chromatography.
8015 DRO ORO	Total Petroleum Hydrocarbons	Method 8015D is used to determine the concentration of various nonhalogenated volatile organic compounds and semivolatile organic compounds by gas chromatography.

TABLE-7

52ND Street Superfund Site Operable Unit 3 Study Area
Extraction and Analytical Procedures

Extraction or Analytical Method	*Application*	*Description*
8310	Polynuclear Aromatic Hydrocarbons	Method 8310 provides high performance liquid chromatographic (HPLC) conditions for the detection of ppb levels of certain olynuclear aromatic hydrocarbons. Prior to use of this method, appropriate sample extraction techniques must be used. A 5- to 25-uL aliquot of the extract is injected into an HPLC, and compounds in the effluent are detected by ultraviolet (UV) and fluorescence detectors.
6010B	Metals	In Test Method 6010B, inductively coupled plasma-atomic emission spectrometry (ICP-AES) determines trace elements, including metals, in solution. All matrices, excluding filtered groundwater samples but including groundwater, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes, require digestion prior to analysis. Groundwater samples that have been prefiltered and acidified will not need acid digestion. Samples which are not digested must either use an internal standard or be matrix matched with the standards.
7470	Mercury	Method 7470 is approved for measuring total mercury (organic and inorganic) in water. Method 7470, a cold-vapor atomic absorption method, is based on the absorption of radiation at the 253.7-nm wavelength by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.
3500-Cr D	Chromium VI	In Method SM3500-Cr D a sample of a known volume is acidified to a pH of 1 ± 0.5 S.U. using a H_2SO_4 solution. Diphenylcarbazide solution is then added to the sample and mixed. Hexavalent chromium reacts with diphenylcarbazide in acidic solution to produce a red-violet color. The sample is allowed to stand for 5 to 10 minutes for full color development. The absorbance of the sample is measured colorimetrically at 540nm on a Spectrophotometer. The concentration of Hexavalent Chromium is then calculated as a function of the absorbance of the prepared sample.

TABLE-7
52ND Street Superfund Site Operable Unit 3 Study Area
Extraction and Analytical Procedures

Extraction or Analytical Method	*Application*	*Description*
9010B	Cyanide	Method 9010 is reflux-distillation procedure used to extract soluble cyanide salts and many insoluble cyanide complexes from wastes and leachates. It is based on the decomposition of nearly all cyanides by a reflux distillation procedure using a strong acid and a magnesium catalyst. Cyanide, in the form of hydrocyanic acid (HCN) is purged from the sample and captured into an alkaline scrubber solution. The concentration of cyanide in the scrubber solution is then determined by Method 9014 or Method 9213. Method 9010 may be used as a reflux-distillation procedure for both total cyanide and cyanide amenable to chlorination. The "reactive" cyanide content of a waste, that is, the cyanide content that could generate toxic fumes when exposed to mild acidic conditions, is not determined by this method.
8082	PCBs	Method 8082 is used to determine the concentrations of polychlorinated biphenyls (PCBs) as Aroclors or as individual PCB congeners in extracts from solid and aqueous matrices. Open tubular, capillary columns are employed with electron capture detectors (ECD) or electrolytic conductivity detectors (ELCD). When compared to packed columns, these fused-silica, open-tubular columns offer improved resolution, better selectivity, increased sensitivity, and faster analysis.
8081A	Pesticides	Method 8081 is used to determine the concentrations of various organochlorine pesticides in extracts from solid and liquid matrices, using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD). When compared to the packed columns, these columns offer improved resolution, better selectivity, increased sensitivity, and faster analysis.

Table-8

52nd Street Superfund Site Operable Unit 3 Study Area

Arizona Data Qualifiers Established by the Arizona Department of Health Services

Microbiology

A1	Too numerous to count.
A2	Sample incubation period exceeded method requirement.
A3	Sample incubation period was shorter than method requirement.
A4	Target organism detected in associated method blank.
A5	Incubator/water bath temperature was outside method requirements.
A6	Target organism not detected in associated positive control.
A7	Micro sample received without adequate headspace.
A8	Plate count was outside the method's reporting range. Reported value is estimated.

Method/Calibration Blank

B1	Target analyte detected in method blank at or above the method reporting limit.
B2	Non-target analyte detected in method blank and sample, producing interference
B3	Target analyte detected in calibration blank at or above the method reporting limit.
B4	Target analyte detected in blank at or above method acceptance criteria.
B5	Target analyte detected in method blank at or above the method reporting limit, but below trigger level or MCL.
B6	Target analyte detected in calibration blank at or above the method reporting limit, but below trigger level or MCL.
B7	Target analyte detected in method blank at or above method reporting limit. Concentration found in the sample was 10 times above the concentration found in the method blank.

Confirmation

C1	Confirmatory analysis not performed as required by the method.
C3	Qualitative confirmation performed.
C4	Confirmatory analysis was past holding time.
C5	Confirmatory analysis was past holding time. Original result not confirmed.
C8	Sample RPD between the primary and confirmatory analysis exceeded 40% per EPA Method 8000C, the lower value was reported as there was not evidence of chromatographic problems.

Dilution

D1	Sample required dilution due to matrix.
D2	Sample required dilution due to high concentration of target analyte.
D4	Minimum Reporting Limit (MRL) adjusted to reflect sample amount received and analyzed.
D5	Minimum Reporting Limit (MRL) adjusted due to sample dilution; analyte was non-detect in the sample.
D6	Minimum Reporting Limit (MRL) adjusted due to an automatic 10X dilution performed on this sample for the purpose of reporting traditional drinking water analytes for wastewater requirements.

Estimated Concentration

E1	Concentration estimated. Analyte exceeded calibration range. Reanalysis not possible due to insufficient sample.
E2	Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to sample matrix.
E3	Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to holding time requirements.
E4	Concentration estimated. Analyte was detected below laboratory minimum reporting limit (MRL).
E5	Concentration estimated. Analyte was detected below laboratory minimum reporting limit (MRL), but not confirmed by alternate analysis.
E6	Concentration estimated. Internal standard recoveries did not meet method acceptance criteria.
E7	Concentration estimated. Internal standard recoveries did not meet laboratory acceptance criteria.
E8	Analyte reported to MDL per project specification. Target analyte was not detected in the sample.

Hold time

H1	Sample analysis performed past holding time.
H2	Initial analysis within holding time. Reanalysis for the required dilution was past holding time.
H3	Sample was received and analyzed past holding time.
H4	Sample was extracted past required extraction holding time, but analyzed within analysis holding time.
H5	This test is specified to be performed in the field within 15 minutes of sampling; sample was received and analyzed past the regulatory holding time.

BOD/CBOD

K1	The sample dilutions set-up for the BOD/CBOD analysis did not meet the oxygen depletion criteria of at least 2 mg/L. Any reported result is an estimated value.
K2	The sample dilutions set up for the BOD/CBOD analysis did not meet the criteria of residual dissolved oxygen of at least 1 mg/L. Any reported result is an estimated value.
K5	The dilution water D.O. depletion was > 0.2 mg/L.
K6	Glucose/glutamic acid BOD/CBOD was below method acceptance criteria.
K7	A discrepancy between the BOD and COD results has been verified by reanalysis of the sample for COD.
K8	Glucose/glutamic acid BOD/CBOD was above method acceptance levels.

Laboratory fortified blank/blank spike

L1	The associated blank spike recovery was above laboratory acceptance limits
L2	The associated blank spike recovery was below laboratory acceptance limits.
L3	The associated blank spike recovery was above method acceptance limits.
L4	The associated blank spike recovery was below method acceptance limits.

Matrix spike

M1	Matrix spike recovery was high; the associated blank spike recovery was acceptable.
M2	Matrix spike recovery was low; the associated blank spike recovery was acceptable.
M3	The spike recovery value is unusable since the analyte concentration in the sample is disproportionate to the spike level. The associated blank spike recovery was acceptable.
M4	The analysis of the spiked sample required a dilution such that the spike recovery calculation does not provide useful information. The associated blank spike recovery was acceptable.
M5	Analyte concentration was determined by the method of standard addition (MSA).
M6	Matrix spike recovery was high. Data reported per ADEQ policy 0154.000.
M7	Matrix spike recovery was low. Data reported per ADEQ policy 0154.000.

General

N1	See case narrative.
N2	See corrective action report.
N4	The Minimum Reporting Limit (MRL) verification check did not meet the laboratory acceptance limit.
N5	The Minimum Reporting Limit (MRL) verification check did not meet the method acceptance limit.
N6	Data suspect due to quality control failure, reported per data user's request.

Table-8

52nd Street Superfund Site Operable Unit 3 Study Area

Arizona Data Qualifiers Established by the Arizona Department of Health Services

Sample Quality

Q1	Sample integrity was not maintained. See case narrative.
Q2	Sample received with head space.
Q3	Sample received with improper chemical preservation.
Q4	Sample received and analyzed without chemical preservation.
Q5	Sample received with inadequate chemical preservation, but preserved by the laboratory.
Q6	Sample was received above recommended temperature.
Q7	Sample inadequately dechlorinated.
Q8	Insufficient sample received to meet method QC requirements. Batch QC requirements satisfy ADEQ policies 0154.000 and 0155.000.
Q9	Insufficient sample received to meet method QC requirements.
Q10	Sample received in inappropriate sample container.
Q11	Sample is heterogeneous. Sample homogeneity could not be readily achieved using routine laboratory practices.

Duplicates

R1	RPD/RSD exceeded the method acceptance limit.
R2	RPD/RSD exceeded the laboratory acceptance limit.
R4	MS/MSD RPD exceeded the method acceptance limit. Recovery met acceptance criteria.
R5	MS/MSD RPD exceeded the laboratory acceptance limit. Recovery met acceptance criteria.
R6	LFB/LFBD RPD exceeded the method acceptance limit. Recovery met acceptance criteria.
R7	LFB/LFBD RPD exceeded the laboratory acceptance limit. Recovery met acceptance criteria.
R8	Sample RPD exceeded the method acceptance limit.
R9	Sample RPD exceeded the laboratory acceptance limit.
R11	The RPD calculation for MS/MSD does not provide useful information due to the varying sample weights when Encore samplers/methanol field preserved samples are used.

Surrogate

S1	Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits.
S3	Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits. No target analytes were detected in the sample.
S4	Surrogate recovery was above laboratory and method acceptance limits. No target analytes were detected in the sample.
S5	Surrogate recovery was below laboratory acceptance limits, but within method acceptance limits.
S6	Surrogate recovery was below laboratory and method acceptance limits. Reextraction and/or reanalysis confirms low recovery caused by matrix effect.
S7	Surrogate recovery was below laboratory and method acceptance limits. Unable to confirm matrix effect.
S8	The analysis of the sample required a dilution such that the surrogate recovery calculation does not provide useful information. The associated blank spike recovery was acceptable.
S10	Surrogate recovery was above laboratory and method acceptance limits. See case narrative.
S11	Surrogate recovery was high. Data reported per ADEQ policy 0154.000.
S12	Surrogate recovery was low. Data reported per ADEQ policy 0154.000.

Method/Analyte Discrepancies

T1	Method approved by EPA, but not yet licensed by ADHS.
T2	Cited ADHS licensed method does not contain this analyte as part of method compound list.
T3	Method not promulgated either by EPA or ADHS.
T4	Tentatively identified compound. Concentration is estimated and based on the closest internal standard.
T5	Laboratory not licensed for this parameter.
T6	The reported result cannot be used for compliance purposes.
T7	Incubator/Oven temperatures were not monitored as required during all days of use.

Calibration Verification

V1	CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.
V2	CCV recovery was above method acceptance limits. This target analyte was detected in the sample. The sample could not be reanalyzed due to insufficient sample.
V3	CCV recovery was above method acceptance limits. This target analyte was detected in the sample, but the sample was not reanalyzed. See case narrative.
V5	CCV recovery after a group of samples was above acceptance limits. This target analyte was not detected in the sample; acceptable per EPA Method 8000C.
V6	Data reported from one-point calibration criteria per ADEQ policy 0155.000.
V9	CCV recovery was below method acceptance limits.

NOTE: Arizona Data Qualifiers updated as of 2007.

Table-9

52nd Street Superfund Site Operable Unit 3 Study Area

Data Evaluation Summary for Method SW-846 8260B Volatile Organic Compounds

QC Check	Minimum Frequency	Acceptance Criteria	Flagging Criteria
Hold Time	All field samples and the associated field QC	Table 7 – all matrices	If the samples were not properly preserved within the specified hold time (HT) qualify detected values Q. If there is documentation of condensation in the sample containers, reject results. If the analytical HT is grossly exceeded (by more than two times the required holding time for volatiles) qualify all positive values as H.
GC/MS Instrument Performance Check	Beginning each 12-hour period during which samples or standards are analyzed.	Must meet the ion abundance criteria stated in Method 8260B	Reject all data acquired under non-compliant tune.
Initial five-point calibration	Initial calibration prior to sample analysis, after instrument changes, or when calibration verification fails.	%RSD ≤ 20% RRF ≥ 0.05. (1,4-dioxane, cis- and trans-1,2-dichloroethene, chloroethane RRF ≥ 0.01).	If using calibration curves and correlation coefficient or coefficient of determination < 0.990, qualify positive values V. If using average RF and %RSD >20%, qualify positive values V, do not qualify non-detects. RRF < 0.05 qualify detects V.
Continuing calibration	To verify the curve, and every 12 hours.	≤±15%D (using average RF) or %Drift (using calibration curves) for all analytes	If %D or %Drift is > ±15%, qualify positive results as V. If the %D or %Drift is > -15%.
Blanks	One per analytical batch per matrix.	No analytes detected > RL	Apply B to all contaminant compound results detected at <5X the amount found in highest blank, and <10X the amount in blank if a common laboratory contaminant is detected (methylene chloride, acetone, 2-butanone or cyclohexane), for all samples in the associated analytical batch. The reviewer will consider blank detected values > MDL < PQL during Level III qualification.
LCS for all analytes specified in Table 1	One LCS sample pair per every 20 samples per matrix.	QC acceptance criteria as presented in Table 1	Batch qualification will be applied as follows: %R for LCS/LCSD >UCL qualify positive values as L. %R for LCS/LCSD <LCL qualify positive values as L. If the %R is < 10% qualify positive values as L. Qualify positive results L if the RPD is > UCL. Use professional judgment for analytes other than spiking analytes.
Surrogates (System Monitoring Compounds)	Every sample, fortified sample, standard, and blank.	QC acceptance criteria as presented in Table 1	If one surrogate fails apply the following qualification to all analyte(s) in the affected sample: %R >UCL or <LCL apply S for detected analytes.
Internal Standards	Every sample, fortified sample, standard, and blank.	Internal standards must be within -50% and +100% of the area for the associated standard.	If the internal standard is less than –50% or greater than +200%, qualify all detected results associated with that IS E. Non-detected results associated with an IS greater than +100% are E. Non-detected results associated with an IS less than –50% are E.

Table-9

52nd Street Superfund Site Operable Unit 3 Study Area

Data Evaluation Summary for Method SW-846 8260B Volatile Organic Compounds

QC Check	Minimum Frequency	Acceptance Criteria	Flagging Criteria
MS/MSD	One MS/MSD sample pair per every 20 samples per matrix.	Meet or exceed QC acceptance criteria as presented in Table 1.	If the MS or MSD recovery is >UCL or <LCL, qualify positive results M. Non-detected analytes are not qualified if the MS or MSD recovery is <LCL. Qualify positive results M if the RPD is >UCL.
Field duplicate comparison	One duplicate pair per 10 site samples.	Per Section 3.5.1.4	If the criteria specified in Section 3.5.1.4 are not met, qualify the primary and field duplicate sample only as R for detected results.
Results reported between MDL and PQL	None	Data will be reported below the RL	Data reported below the RL will be qualified E.

Notes:

Q – chemical preservation inadequate, or sample integrity not maintained
H – holding time exceeded
E - estimated, detected
B – method or calibration blank did not meet criteria
L – blank spike recovery was above or below limits
V – calibration verification is above or below acceptance limits
S – surrogate recovery above or below laboratory acceptance limits
M – matrix spike recovery was high or low
LCL - lower control limit
UCL - upper control limit
%R - percent recovery
%RSD - percent relative standard deviation
RPD - relative percent difference
%D - percent difference
RRF- relative response factor
CRQL - contract required quantitation limit
LCS/LCSD - lab control sample/Lab control sample duplicate
MS/MSD - matrix spike/matrix spike duplicate
QC - quality control

The method does not require an LCS; there are instances when the laboratory does not have sufficient sample volume to perform MS/MSD analyses and will report an LCS/LCSD for the batch.

Table-10

52nd Street Superfund Site Operable Unit 3 Study Area

Data Evaluation Summary for Method TO-15 Volatile Organic Compounds

QC Check	*Minimum Frequency*	*Acceptance Criteria*	*Flagging Criteria*
Hold Time	All field samples and the associated field QC	Table 7 – soil vapor	If the samples were not properly preserved within the specified hold time (HT) qualify detected values Q. If there is documentation of condensation in the sample containers, reject results. If the analytical HT is grossly exceeded (by more than two times the required holding time for volatiles) qualify all positive values as H. Do not qualify non detected values.
GC/MS Instrument Performance Check	Beginning each 24-hour period during which samples or standards are analyzed.	Must meet the ion abundance criteria stated in EPA Method 8260B	Reject all data acquired under non-compliant tune.
Initial five-point calibration	Initial calibration prior to sample analysis, after instrument changes, or when calibration verification fails.	%RSD ≤ 30% RRF ≥ 0.05 (1,4-dioxane, cis- and trans-1,2-dichloroethene, chloroethane RRF ≥ 0.01).	%RSD >30%, qualify positive values V, and do not qualify non detects. RRF < criterion, qualify detects V and do not qualify non-detects.
Continuing calibration	To verify the curve, and every 24 hours.	≤±30%D (using average RF)	If %D > ±30%, qualify positive results as V. If the %D > -30%, do not qualify non-detects.
Blanks	One per analytical batch per matrix.	No analytes detected > RL	Apply B to all contaminant compound results detected at <5X the amount found in highest blank. The reviewer will consider blank detected values > MDL < PQL during Level III qualification.
LCS for all analytes specified in Table 1	One LCS sample pair per every 20 samples.	QC acceptance criteria as presented in Table 1	Batch qualification will be applied as follows: %R for LCS/LCSD >UCL qualify positive values as L. %R for LCS/LCSD <LCL qualify positive values as L and non detected values as UJ. If the %R is < 10% qualify positive values as L, non detected values will not be qualified. Qualify positive results L if the RPD is > UCL. Use professional judgment for analytes other than spiking analytes.
Internal Standards	Every sample, fortified sample, standard, and blank.	Internal standards must be within +/- 40% of the area for the associated standard.	If the internal standard is less than 60% or greater than +140%, qualify all detected results associated with that IS E. Non-detected results associated with an IS greater than +140% are not qualified. Non-detected results associated with an IS less than –60% are E. Extremely low area counts require non-detected results to not be qualified.
Field duplicate comparison	One duplicate pair per 10 site samples.	Per Section 3.5.1.4	If the criteria are not met, qualify the primary and field duplicate sample only as R for detected results, do not qualify ND results.

Table-10

52nd Street Superfund Site Operable Unit 3 Study Area

Data Evaluation Summary for Method TO-15 Volatile Organic Compounds

QC Check	*Minimum Frequency*	*Acceptance Criteria*	*Flagging Criteria*
Results reported between MDL and PQL	None	Data will be reported below the RL	Data reported below the RL will be qualified E.
TICs	None	TICs will not be reported for this program.	

Notes:

Q – chemical preservation inadequate, or sample integrity not maintained
H – holding time exceeded
E - estimated, detected
B – method or calibration blank did not meet criteria
L – blank spike recovery was above or below limits
V – calibration verification is above or below acceptance limits
S – surrogate recovery above or below laboratory acceptance limits
M – matrix spike recovery was high or low
LCL - lower control limit
UCL - upper control limit
%R - percent recovery
%RSD - percent relative standard deviation
RPD - relative percent difference
%D - percent difference
RRF- relative response factor
CRQL - contract required quantitation limit
LCS/LCSD - lab control sample/Lab control sample duplicate
MS/MSD - matrix spike/matrix spike duplicate
QC - quality control

The method does not require an LCS; there are instances when the laboratory does not have sufficient sample volume to perform MS/MSD analyses and will report an LCS/LCSD for the batch.

Table-11

52nd Street Superfund Site Operable Unit 3 Study Area
Data Evaluation Summary for Method SW-846 8270C

QC Check	Minimum Frequency	Acceptance Criteria	Flagging Criteria
Hold Time	All field samples and the associated field QC	Table7 – all matrices	If the samples were not properly preserved qualify detected values H. Do not qualify non detected values. If the analytical HT is grossly exceeded (by more than two times the required holding time for volatiles) qualify all positive values as H and do not qualify non detected values.
GC/MS Instrument Performance Check	Beginning each 12-hour period during which samples or standards are analyzed.	Must meet the ion abundance criteria stated in Method 8270C	Reject all data acquired under non-compliant tune.
Initial five-point calibration	Initial calibration prior to sample analysis, after instrument changes, or when calibration verification fails.	%RSD ≤ 30% for dioxane and method CCCs; ≤15% for remaining analytes. RRF ≥ 0.05.	If using average RF and %RSD >limit, qualify positive values V, and do not qualify non-detects. RRF < 0.05 qualify detects V and do not qualify non-detects.
Continuing calibration	To verify the curve, and every 12 hours.	≤±20%D (using average RF) or %Drift (using calibration curves) for all analytes	If %D or %Drift is > ±20%, qualify positive results as V. If the %D or %Drift is > -20%, qualify non-detects V.
Blanks	One per analytical batch per matrix.	No analytes detected > RL	Apply B to all contaminant compound results detected at <5X the amount found in highest blank, and <10X the amount in blank if the common laboratory contaminant bis-2-ethylhexylphthalate is detected, for all samples in the associated analytical batch. The reviewer will consider blank detected values > MDL < PQL during Level III qualification.
LCS for all analytes specified	One LCS sample pair per analytical batch or every 20 samples per matrix, whichever is more frequent.	QC acceptance criteria as presented in Table 1	Batch qualification will be applied as follows: %R for LCS/LCSD >UCL qualify positive values as L. %R for LCS/LCSD <LCL qualify positive values as L, non detected values will not be qualified. If the %R is < 10% qualify positive values as L and non detected values will not be qualified. Qualify positive results L if the RPD is > UCL. Use professional judgment for analytes other than spiking analytes.
Surrogates (System Monitoring Compounds)	Every sample, fortified sample, standard, and blank.	QC acceptance criteria as presented in Table 1	If one surrogate fails apply the following qualification to all associated analyte(s) in the affected sample: %R >UCL or <LCL apply S for detected analytes, %R < LCL but > 10% R apply S for non detected analytes If surrogate %R is < 10% do not qualify non detected analytes.

Table-11

52nd Street Superfund Site Operable Unit 3 Study Area
Data Evaluation Summary for Method SW-846 8270C

QC Check	Minimum Frequency	Acceptance Criteria	Flagging Criteria
Internal Standards	Every sample, fortified sample, standard, and blank.	Internal standards must be within -50% and +100% of the area for the associated standard.	If the internal standard is less than –50% or greater than +100%, qualify all detected results associated with that IS E. Non-detected results associated with an IS greater than +100% are not qualified. Non-detected results associated with an IS less than –50% are qualified E. Non-detected results will not be qualified.
MS/MSD	One MS/MSD sample pair per every 20 samples per matrix.	Meet or exceed QC acceptance criteria as presented in Table 1.	If the MS or MSD recovery is >UCL or <LCL, qualify positive results M. Non-detected analytes are not qualified if the MS or MSD recovery is <LCL. Qualify positive results M if the RPD is >UCL.
Field duplicate comparison	One duplicate pair per 10 site samples.	Per Section 3.5.1.4	If the criteria specified in Section 3.5.1.4 are not met, qualify the primary and field duplicate sample only as R for detected results and do not qualify ND results.
Results reported between MDL and PQL	None	Data will be reported below the RL	Data reported below the RL will be qualified E.
TICs	None	TICs will not be reported for this program.	

Notes:
Q – chemical preservation inadequate, or sample integrity not maintained
H – holding time exceeded
E - estimated, detected
B – method or calibration blank did not meet criteria
L – blank spike recovery was above or below limits
V – calibration verification is above or below acceptance limits
S – surrogate recovery above or below laboratory acceptance limits
M – matrix spike recovery was high or low
LCL-lower control limit
UCL-upper control limit
%R-percent recovery
%RSD-percent relative standard deviation
RPD-relative percent difference
%D-percent difference
RRF- relative response factor
CRQL-contract required quantitation Limit
LCS/LCSD-lab control sample/
Lab control sample duplicate
MS/MSD-matrix spike/matrix spike duplicate
QC-quality control

The method does not require an LCS; there are instances when the laboratory does not have sufficient sample volume to perform MS/MSD analyses and will report an LCS/LCSD for the batch.

Appendix A
Laboratory Certifications and Quality Assurance Manual

Arizona Department of Health Services

ENVIRONMENTAL LABORATORY LICENSE

Issued to:

Laboratory Director: **Elizabeth Wueschner**
Owner/Representative: **Rachel Brydon Jannetta**

TestAmerica Phoenix - Cotton Center
AZ0728

is in compliance with Environmental Laboratory's applicable standards for the State of Arizona and maintains on file a List of Parameters for which the laboratory is certified to perform analysis.

PERIOD OF LICENSURE FROM: 06/10/2008 TO: 06/09/2009

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Steven D. Baker, Chief
Office of Laboratory Services
Bureau of State Laboratory Services

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Monday, August 4 2008

AZ License: **AZ0728**

Lab Director: **Ms. Elizabeth Wueschner**

Lab Name: TestAmerica Phoenix - Cotton Center
Phone: (602) 437-3340
Fax: (602) 454-9303

Program **AIR**

Parameter	EPA Method	Billing Code	Cert Date
Volatile Organic Compounds	METHOD TO-15	AIR17	03/18/08

Total Licensed Parameters in this Program: 1

Program **HW**

Parameter	EPA Method	Billing Code	Cert Date
Alumina Cleanup	EPA 3610B	PREP2	03/18/08
Aluminum	EPA 6010B	MTL3	03/18/08
Aluminum	EPA 6020	MTL7	03/18/08
Antimony	EPA 6010B	MTL3	03/18/08
Antimony	EPA 6020	MTL7	03/18/08
Aromatic & Halogenated Vocs	EPA 8021B	VOC1	04/23/08
Arsenic	EPA 6010B	MTL3	03/18/08
Arsenic	EPA 6020	MTL7	03/18/08
Barium	EPA 6010B	MTL3	03/18/08
Barium	EPA 6020	MTL7	03/18/08
Beryllium	EPA 6010B	MTL3	03/18/08
Beryllium	EPA 6020	MTL7	03/18/08
Bromide	EPA 9056	NIIIA1	05/05/08
C10-C32 Hydrocarbons	8015AZ1	VOC4	03/18/08
Cadmium	EPA 6010B	MTL3	03/18/08
Cadmium	EPA 6020	MTL7	03/18/08
Calcium	EPA 6010B	MTL3	03/18/08
Chloride	EPA 9056	NIIIA1	05/05/08
Chlorin. Herbs By Gc Methylation	EPA 8151A	SOC9	03/18/08
Chromium Total	EPA 6010B	MTL3	03/18/08
Chromium Total	EPA 6020	MTL7	03/18/08
Closed System Purge And Trap Extract. Vocs	EPA 5035A	PREP2	03/18/08
Cobalt	EPA 6010B	MTL3	03/18/08
Cobalt	EPA 6020	MTL7	03/18/08
Continious Liquid-Liquid Extraction	EPA 3520C	PREP2	03/18/08
Copper	EPA 6010B	MTL3	03/18/08
Copper	EPA 6020	MTL7	03/18/08
Corrosivity Ph Determination	EPA 9040C	HAZ1	03/18/08
Cyanide	EPA 9010C	PREP2	03/18/08
Cyanide	EPA 9014	MISC7	03/18/08
Cyanide Extractions For Solids And Oils	EPA 9013A	PREP3	03/18/08
Dissolved In Water	EPA 3005A	PREP1	03/18/08
Flashpoint Determination	EPA 1030	HAZ2	03/18/08
Fluoride	EPA 9056	NIIIA1	05/05/08

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Program **HW**

Parameter	EPA Method	Billing Code	Cert Date
Hydrogen Ion (Ph)	EPA 9041A	NIA6	05/12/08
Hydrogen Ion (Ph)	EPA 9045D	NIA6	03/18/08
Ignitability (Flash Point)	EPA 1010A	HAZ2	03/18/08
Iron	EPA 6010B	MTL3	03/18/08
Lead	EPA 6010B	MTL3	03/18/08
Lead	EPA 6020	MTL7	03/18/08
Magnesium	EPA 6010B	MTL3	03/18/08
Manganese	EPA 6010B	MTL3	03/18/08
Manganese	EPA 6020	MTL7	03/18/08
Mercury	EPA 7470A	MTL5	03/18/08
Mercury	EPA 7471A	MTL5	03/18/08
Molybdenum	EPA 6010B	MTL3	03/18/08
Nickel	EPA 6010B	MTL3	03/18/08
Nickel	EPA 6020	MTL7	03/18/08
Nitrate	EPA 9056	NIIIA1	05/05/08
Nitrite	EPA 9056	NIIIA1	05/05/08
Nonhalogenated Organics Using Gc/Fid	EPA 8015D	VOC4	04/23/08
Oil & Grease &Petroleum Hydrocarbons	EPA 1664A	MISC6	03/18/08
Organochlorine Pesticides By Gc	EPA 8081A	SOC9	03/18/08
Organophosphorus Pesticides By Gc	EPA 8141A	SOC9	03/18/08
Ortho-Phosphate	EPA 9056	NIIIA1	05/05/08
Pahs	EPA 8310	SOC13	03/18/08
Paint Filter Liquids Test	EPA 9095B	MISC18	03/18/08
Pcbs By Gc	EPA 8082	SOC9	03/18/08
Perchlorate	EPA 314.0	NIB5	03/18/08
Potassium	EPA 6010B	MTL3	03/18/08
Pressurized Fluid Extraction	EPA 3545	PREP2	03/18/08
Purge And Trap For Aqueous Samples	EPA 5030C	PREP2	03/18/08
Sediments, Sludges And Soils	EPA 3050B	PREP1	03/18/08
Selenium	EPA 6010B	MTL3	03/18/08
Semivolatile Compounds By Gc/Ms	EPA 8270C	SOC16	03/18/08
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	PREP2	03/18/08
Silica Gel Cleanup	EPA 3630C	PREP2	03/18/08
Silver	EPA 6010B	MTL3	03/18/08
Silver	EPA 6020	MTL7	03/18/08
Sodium	EPA 6010B	MTL3	03/18/08
Splp	EPA 1312	HAZ6	03/18/08
Strontium	EPA 6010B	MTL3	03/18/08
Sulfate	EPA 9056	NIIIA1	05/05/08
Sulfur Cleanup	EPA 3660B	PREP2	03/18/08
Sulfuric Acid/Permanganate Cleanup	EPA 3665A	PREP2	03/18/08

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Program **HW**

Parameter	EPA Method	Billing Code	Cert Date
Tclp	EPA 1311	HAZ5	03/18/08
Thallium	EPA 6010B	MTL3	03/18/08
Thallium	EPA 6020	MTL7	03/18/08
Tin	EPA 6010B	MTL3	03/18/08
Tocs	EPA 9060A	MISC2	03/18/08
Total Chlorine In Petroleum Products	EPA 9077	NIA2	03/18/08
Total Metals	EPA 3010A	PREP1	03/18/08
Total Recoverable In Water	EPA 3005A	PREP1	03/18/08
Ultrasonic Extraction	EPA 3550B	PREP2	03/18/08
Vanadium	EPA 6010B	MTL3	03/18/08
Vocs By Gc/Ms	EPA 8260B	VOC8	03/18/08
Waste Dilution	EPA 3580A	PREP2	03/18/08
Zinc	EPA 6010B	MTL3	03/18/08
Zinc	EPA 6020	MTL7	03/18/08

Total Licensed Parameters in this Program: 89

Program **SDW**

Parameter	EPA Method	Billing Code	Cert Date
Alkalinity	SM 2320B	NIA1	03/18/08
Aluminum	EPA 200.7	MTL3	03/18/08
Aluminum	EPA 200.8	MTL7	03/18/08
Antimony	EPA 200.8	MTL7	03/18/08
Arsenic	EPA 200.8	MTL7	03/18/08
Barium	EPA 200.7	MTL3	03/18/08
Barium	EPA 200.8	MTL7	03/18/08
Beryllium	EPA 200.7	MTL3	03/18/08
Beryllium	EPA 200.8	MTL7	03/18/08
Bromide	EPA 300.0	NIIIA1	05/12/08
Cadmium	EPA 200.7	MTL3	03/18/08
Cadmium	EPA 200.8	MTL7	03/18/08
Calcium	EPA 200.7	MTL3	03/18/08
Carbon, Dissolved Organic	SM 5310B	MISC1	03/18/08
Carbon, Total Organic	SM 5310B	MISC1	03/18/08
Chloride	EPA 300.0	NIIIA1	03/18/08
Chlorine Total Residual	HACH 8167	NIA3	03/18/08
Chromium Total	EPA 200.7	MTL3	03/18/08
Chromium Total	EPA 200.8	MTL7	03/18/08
Copper	EPA 200.7	MTL3	03/18/08
Copper	EPA 200.8	MTL7	03/18/08
Corrosivity	SM 2330B	NIA5	03/18/08
Cyanide	SM 4500 CN E	MISC7	03/18/08

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Program **SDW**

Parameter	EPA Method	Billing Code	Cert Date
Cyanide Amenable To Chlorination	SM 4500-CN G	MISC7	03/18/08
Fecal Coliform	SM 9221E	MIC5	03/18/08
Fecal Coliform	SM 9222D	MIC5	03/18/08
Fluoride	EPA 300.0	NIIIA1	03/18/08
Hardness	SM 2340B	MTL3	05/12/08
Heterotrophic Bacteria	SIMPLATE	MIC9	03/18/08
Heterotrophic Plate Count	SM 9215B	MIC9	03/18/08
Hydrogen Ion (Ph)	SM 4500-H B	NIA6	03/18/08
Iron	EPA 200.7	MTL3	03/18/08
Lead	EPA 200.8	MTL7	03/18/08
Magnesium	EPA 200.7	MTL3	03/18/08
Manganese	EPA 200.7	MTL3	03/18/08
Manganese	EPA 200.8	MTL7	03/18/08
Mercury	EPA 245.1	MTL5	03/18/08
Nickel	EPA 200.7	MTL3	03/18/08
Nickel	EPA 200.8	MTL7	03/18/08
Nitrate	EPA 300.0	NIIIA1	03/18/08
Nitrite	EPA 300.0	NIIIA1	03/18/08
Nitrite	SM 4500-NO2 B	NIIB4	03/18/08
Orthophosphate	EPA 300.0	NIIIA1	03/18/08
Orthophosphate	SM 4500-P E	NIIB5	03/18/08
Perchlorate	EPA 314.0	NIB5	03/18/08
Residue, Filterable (Tds)	SM 2540C	NIIA8	03/18/08
Selenium	EPA 200.8	MTL7	03/18/08
Silica	EPA 200.7	MTL3	03/18/08
Silver	EPA 200.7	MTL3	03/18/08
Silver	EPA 200.8	MTL7	03/18/08
Sodium	EPA 200.7	MTL3	03/18/08
Specific Conductance	SM 2510B	NIA7	03/18/08
Strontium	EPA 200.7	MTL3	03/18/08
Sulfate	EPA 300.0	NIIIA1	03/18/08
Temperature	SM 2550	NIA18	03/18/08
Thallium	EPA 200.8	MTL7	03/18/08
Total Coliforms And E. Coli By Colilert	SM 9223B	MIC3	03/18/08
Total Coliforms By Mtf	SM 9221B & C	MIC1	03/18/08
Turbidity, Ntu: Nephelometric	EPA 180.1	NIA9	03/18/08
Uranium	EPA 200.8	MTL7	03/18/08
Vocs By Gc-Ms	EPA 524.2	VOC1	03/18/08
Zinc	EPA 200.7	MTL3	03/18/08
Zinc	EPA 200.8	MTL7	03/18/08

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Program **SDW**

Parameter	EPA Method	Billing Code	Cert Date

Total Licensed Parameters in this Program: 63

Program **WW**

Parameter	EPA Method	Billing Code	Cert Date
Alkalinity, Total	SM 2320B	NIA1	03/18/08
Aluminum	EPA 200.7	MTL3	03/18/08
Aluminum	EPA 200.8	MTL7	03/18/08
Ammonia	SM 4500-NH3D	NIIB1	03/18/08
Antimony	EPA 200.7	MTL3	03/18/08
Antimony	EPA 200.8	MTL7	03/18/08
Arsenic	EPA 200.7	MTL3	03/18/08
Arsenic	EPA 200.8	MTL7	03/18/08
Barium	EPA 200.7	MTL3	03/18/08
Barium	EPA 200.8	MTL7	03/18/08
Base/Neutrals And Acids Excluding Pesticides	EPA 625	SOC16	03/18/08
Beryllium	EPA 200.7	MTL3	03/18/08
Beryllium	EPA 200.8	MTL7	03/18/08
Biochemical Oxygen Demand	SM 5210B	DEM1	03/18/08
Boron	EPA 200.7	MTL3	03/18/08
Bromide	EPA 300.0	NIIIA1	03/18/08
Cadmium	EPA 200.7	MTL3	03/18/08
Cadmium	EPA 200.8	MTL7	03/18/08
Calcium	EPA 200.7	MTL3	03/18/08
Chemical Oxygen Demand	SM 5220D	DEM2	03/18/08
Chloride	EPA 300.0	NIIIA1	03/18/08
Chlorine Residual Total	HACH 8167	NIA3	03/18/08
Chromium Total	EPA 200.7	MTL3	03/18/08
Chromium Total	EPA 200.8	MTL7	03/18/08
Chromium, Hexavalent	SM 3500-CR D	MTL8	03/18/08
Cobalt	EPA 200.7	MTL3	03/18/08
Cobalt	EPA 200.8	MTL7	03/18/08
Copper	EPA 200.7	MTL3	03/18/08
Copper	EPA 200.8	MTL7	03/18/08
Cyanide Amenable To Chlorination	SM 4500-CN G	MISC7	03/18/08
Cyanide, Total	SM 4500-CN BC	MISC34	03/18/08
E. Coli By Colilert Mpn	SM 9223B	MIC3	03/18/08
E. Coli (Not For Npdes) In Conjunction	SM 9221F	MIC3	03/18/08
Fecal Coliforms By Membrane Filter	SM 9222D	MIC6	03/18/08
Fecal Coliforms By Mtf (May Be Used For Sludge)	SM 9221E	MIC5	03/18/08
Fluoride	EPA 300.0	NIIIA1	03/18/08
Hardness	SM 2340B	NIA5	05/12/08

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Program **WW**

Parameter	EPA Method	Billing Code	Cert Date
Hydrogen Ion (Ph)	SM 4500-H B	NIA6	03/18/08
Iron	EPA 200.7	MTL3	03/18/08
Kjeldahl Nitrogen	SM 4500-NORG C	NIIB3	05/12/08
Lead	EPA 200.7	MTL3	03/18/08
Lead	EPA 200.8	MTL7	03/18/08
Lithium	EPA 200.7	MTL3	03/18/08
Magnesium	EPA 200.7	MTL3	03/18/08
Manganese	EPA 200.7	MTL3	03/18/08
Manganese	EPA 200.8	MTL7	03/18/08
Mercury	EPA 245.1	MTL5	03/18/08
Molybdenum	EPA 200.7	MTL3	03/18/08
Molybdenum	EPA 200.8	MTL7	03/18/08
Nickel	EPA 200.7	MTL3	03/18/08
Nickel	EPA 200.8	MTL7	03/18/08
Nitrate	EPA 300.0	NIIIA1	03/18/08
Nitrate-Nitrite (As N)	EPA 300	NIIIA1	05/12/08
Nitrite (As N)	EPA 300.0	NIIIA1	03/18/08
Nitrite (As N)	SM 4500-NO2 B	NIIB4	03/18/08
Oil And Grease	EPA 1664A	MISC6	03/18/08
Organochlorine Pesticides And Polychlorinated Biphenyls	EPA 608	SOC9	03/18/08
Organophosphorus Pesticides	EPA 1657	SOC10	03/18/08
Orthophosphate	EPA 300.0	NIIIA1	03/18/08
Orthophosphate	SM 4500-P E	NIIB5	03/18/08
Phosphorus Total	SM 4500-P B	NIIB6	03/18/08
Phosphorus Total	SM 4500-P E	NIIB6	03/18/08
Potassium	EPA 200.7	MTL3	03/18/08
Purgeables	EPA 624	VOC8	03/18/08
Residue Filterable	SM 2540C	NIA8	03/18/08
Residue Nonfilterable	SM 2540D	NIIA5	03/18/08
Residue Total	SM 2540B	NIIA4	03/18/08
Residue Volatile	EPA 160.4	NIIA7	03/18/08
Residue, Settleable Solids	SM 2540F	NIIA6	03/18/08
Selenium	EPA 200.7	MTL3	03/18/08
Selenium	EPA 200.8	MTL7	03/18/08
Silica, Dissolved	EPA 200.7	MTL3	03/18/08
Silver	EPA 200.7	MTL3	03/18/08
Silver	EPA 200.8	MTL7	03/18/08
Sodium	EPA 200.7	MTL3	03/18/08
Specific Conductance	SM 2510B	NIA7	03/18/08
Strontium	EPA 200.7	MTL3	03/18/08

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Program **WW**

Parameter	EPA Method	Billing Code	Cert Date
Sulfate	EPA 300.0	NIIIA1	03/18/08
Sulfide	SM 4500-S D	MISC11	03/18/08
Temperature, Degrees Celcius	SM 2550B	NIA18	03/18/08
Thallium	EPA 200.7	MTL3	03/18/08
Thallium	EPA 200.8	MTL7	03/18/08
Tin	EPA 200.7	MTL3	03/18/08
Tin	EPA 200.8	MTL7	07/10/08
Total Coliforms By Mtf	SM 9221B	MIC1	03/18/08
Total Organic Carbon	SM 5310B	MISC1	03/18/08
Total, Fixed And Volatile Solids In Sludge	SM 2540G	NIIA7	03/18/08
Turbidity	EPA 180.1	NIA9	03/18/08
Vanadium	EPA 200.7	MTL3	03/18/08
Vanadium	EPA 200.8	MTL7	03/18/08
Zinc	EPA 200.7	MTL3	03/18/08
Zinc	EPA 200.8	MTL7	03/18/08

Total Licensed Parameters in this Program: 92

Instruments	Quantity	Date
GAS CHROMATOGRAPH/MASS SPECTROMETER	12	05/12/08
GAS CHROMATOGRAPH	8	05/12/08
ION CHROMATOGRAPH	5	05/12/08
HIGH PERFORMANCE LIQUID CHROMATOGRAPH	2	03/18/08
MERCURY ANALYZER	2	05/12/08
AUTOMATED AUTOANALYZER	2	03/18/08
INDUCTIVELY COUPLED PLASMA SPECTROMETER	2	03/18/08
INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETER	1	03/18/08
TOTAL ORGANIC HALIDE	1	05/12/08

Softwares
ENVIROQUANT - GC
PERKIN ELMER - ICP
PERKIN ELMER - ICP/MS
HP CHEMSTATION-HPLC
EZ CHROM - GC
CHROMELEON (DIONEX) - IC
1-FIMS - MERCURY ANALYZER
SHIMADZU-LAB SOLUTIONS
ENVIROQUANT/CHEMSTATION GC/MS
PEAKNET (DIONEX) - IC

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MANTECH

Cover Page:

Quality Assurance Manual

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Quality Assurance Manual
Approval Signatures

Laboratory Director – Elizabeth Wueschner	4/21/2008 Date
Quality Assurance Manager – Anne Nichols	2/8/2008 Date
Quality Assurance Manager - David Schreiner	2/8/2008 Date
Operations Manager – Shawn Kusma	2/25/2008 Date

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SECTION 2

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5	Glossary / Acronyms	Appendix 5-1	4/22/2008
6	Laboratory Certifications, Accreditations, Validations	Appendix 6-1	4/22/2008
7	Data Qualifiers	Appendix 7-1	4/22/2008

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SOPs AND POLICIES REFERRED TO IN THE QA MANUAL

SOP/Policy Reference	Title
CA-Q-S-001	Solvent and Acid Lot Testing and Approval
CA-Q-S-002	Acceptable Manual Integration Practices
CA-Q-S-004	Method Compliance & Data Authenticity Audits
CA-Q-S-005	Calibration Curves (General)
CW-Q-S-001	Corporate Document Control and Archiving
CW-Q-S-002	Writing a Standard Operating Procedure (SOPs)
CA-L-S-001	Internal Investigation of Potential Data Discrepancies and Determination for Data Recall
CA-L-S-002	Subcontracting Procedures
CA-L-P-001	Ethics Policy
CA-L-P-002	Contract Compliance Policy
CW-L-P-001	Record Retention
CW-F-P-002	Authorization Matrix
CA-C-S-001	Work Sharing Process
CA-T-P-001	Qualified Products List
CW-F-S-004	Controlled Purchases Policy
PE-ADM-024	Computer Security
PE-COR-008	Calibration Curves (General)
PE-PMD-001	Project Management Data Reporting, Validation and Distribution
PE-PMD-002	Project Management Communication and Documentation
PE-PMD-003	Project Management – Client/Project Set-up
PE-QAD-001	Control Charts and Statistical Process Control
PE-QAD-003	Data Package Coordinator

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PE-QAD-004	Thermometer Calibration
PE-QAD-006	Logbook Documentation
PE-QAD-007	Corrective Actions
PE-QAD-008	Training and Documentation
PE-QAD-009	Manual Integration / Data Integrity
PE-QAD-010	Document Control
PE-QAD-013	Reagent and Standard Control and Documentation
PE-QAD-014	Creation and Maintenance of SOPs
PE-QAD-016	Analytical Balance Calibration
PE-QAD-018	Data Qualifiers
PE-QAD-021	Determination of Method Detection Limits
PE-QAD-024	General Data Review Procedure
PE-QAD-031	Calibration and Measurement Uncertainty
PE-QAD-032	Reporting Analytical Data
PE-SFT-001	Laboratory Waste Disposal
PE-SMP-001	Sample Receipt and Login
PE-SMP-004	Field Sampling
PE-SMP-006	General Supplies and Chemical Receipt Process
PE-SMP-007	Calibrating Sampling Pumps

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SECTION 3

INTRODUCTION
(NELAC 5.1 - 5.3)

3.1 INTRODUCTION AND COMPLIANCE REFERENCES

TestAmerica Phoenix's Quality Assurance Manual (QAM) is a document prepared to define the overall policies, organization objectives and functional responsibilities for achieving TestAmerica's data quality goals. Each TestAmerica laboratory maintains a local perspective in its scope of services and client relations and maintains a national perspective in terms of quality.

The QAM has been prepared to assure compliance with the 2003 National Environmental Laboratory Accreditation Conference (NELAC) standards and ISO/IEC Guide 17025 (2005). In addition, the policies and procedures outlined in this manual are compliant with the various accreditation and certification programs listed in Appendix 6. The relevant NELAC section is included in the heading of each QAM section. The QAM has been prepared to be consistent with the requirements of the following documents:

- EPA 600/R-95/131, *Methods for the Determination of Organic Compounds in Drinking Water,* Supplement III, EPA, August 1995.
- EPA 600/4-79-019, *Handbook for Analytical Quality Control in Water and Wastewater Laboratories,* EPA, March 1979.
- EPA SW-846, *Test Methods for the Evaluation of Solid Waste, 3rd Edition,* September 1986; Update I, July 1992; Update II, September 1994; and Update III, December 1996.
- Federal Register, 40 CFR Parts 136, 141, 172, 173, 178, 179 and 261.
- APHA, *Standard Methods for the Examination of Water and Wastewater,* 20th Edition.
- Toxic Substances Control Act (TSCA).
- Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA, Second Edition, 1999.
- NIOSH Manual of Analytical Methods, Fourth Edition, 1994.
- U. S. Department of Labor, Occupational Safety & Health Administration, Index of Sampling & Analytical Methods, Revision Date: 21 November 2001.
- AIHA Policies for Laboratory Quality Assurance Programs, April 1, 2007.

3.2 TERMS AND DEFINITIONS

A Quality Assurance Program is a company-wide system designed to ensure that data produced by TestAmerica Phoenix conforms to the standards set by state and/or federal regulations. The program functions at the management level through company goals and management policies, and at the analytical level through Standard Operating Procedures (SOPs) and quality control. The TestAmerica program is designed to minimize systematic error, encourage constructive, documented problem solving, and provide a framework for continuous improvement within the organization.

Refer to Appendix 5 for the Glossary/Acronyms.

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3.3 SCOPE / FIELDS OF TESTING

TestAmerica Phoenix analyzes thousands of environmental and industrial samples every month. Sample matrices vary among air, drinking water, effluent water, groundwater, hazardous waste, sludge, soils and industrial hygiene. The Quality Assurance Program contains specific procedures and methods to test samples of differing matrices for chemical, physical and biological parameters. The Program also contains guidelines on maintaining documentation of analytical process, reviewing results, servicing clients and tracking samples through the laboratory. The technical and service requirements of all requests to provide analyses are thoroughly evaluated before commitments are made to accept the work. Measurements are made using published reference methods or methods developed and validated by the laboratory.

The methods covered by this manual include the most frequently requested water, air, industrial waste, and soil methodologies needed to provide analytical services in the United States and its territories. The specific list of test methods used by the laboratory can be found in the SOP Table of Contents (controlled documents directory). The approach of this manual is to define the minimum level of quality assurance and quality control necessary to meet requirements. All methods performed by TestAmerica Phoenix shall meet these criteria as appropriate. In some instances, quality assurance project plans (QAPPs), project specific data quality objectives (DQOs) or local regulations may require criteria other than those contained in this manual. In these cases, the laboratory will abide by the requested criteria following review and acceptance of the requirements by the Laboratory Director, Account Executive, Client Services Manager and/or the Quality Assurance (QA) Manager. In some cases, QAPPs and DQOs may specify less stringent requirements. The Laboratory Director and the QA Manager must determine if it is in the lab's best interest to follow the less stringent requirements.

3.4 MANAGEMENT OF THE MANUAL

3.4.1 Review Process

The manual is reviewed annually by the QA Manager and laboratory personnel to assure that it reflects current practices and meets the requirements of TestAmerica Phoenix's clients and regulators. Occasionally, the manual may need changes in order to meet new or changing regulations and operations. The QA Manager will review the changes in the normal course of business and incorporate changes into revised sections of the document. The updates will be reviewed by the QA Manager, Laboratory Director, Technical Director(s), relevant operational staff and Corporate Quality Assurance (if a change is made to the Corporate template) and then formally incorporated into the document in periodic updates. The QAM is based on a Corporate QAM Template that is prepared and approved by the Chief Operating Officer (COO) and Corporate Quality Assurance. This template is reviewed annually by the COO, Corporate Quality, and each laboratory. Necessary changes are coordinated by the Vice President of Quality and Environmental Health & Safety (EHS) and distributed to each laboratory for inclusion in the laboratory specific QA Manuals.

Policies in the QAM that require immediate attention may be addressed through the use of Corporate QA/QC Policy Memoranda. QA/QC Policy Memoranda are published from time to time to facilitate immediate changes to QA/QC Policy. QA/QC Policy Memoranda supersede the QAM and all other SOPs (refer to Section 5.3). All policy memoranda are dated, archived

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and distributed by their placement into the front of the QAM between the signature page and Section 2. At a minimum, each policy memorandum is approved by the same authorized signatories as shown on the cover page of the QA Manual. In addition, Corporate QA/QC Policy Memoranda are signed by the COO and VP of Quality and EHS. The QA/QC Policy Memoranda are incorporated into the QAM during the periodic updates. Policy memorandum may also include an expiration date if appropriate. An example format can be found in Figure 3-1. A similar procedure is followed for local laboratory changes.

Laboratory-specific QAM changes are approved and documented through the Management of Change process (Refer to SOP No. CA-Q-S-003, Management of Change Procedure).

3.4.2 Control

This manual is considered confidential within TestAmerica and may not be altered in any manner by other than a duly appointed representative from TestAmerica. If the document has been provided to external users or regulators, it is for the exclusive purpose of reviewing TestAmerica's quality systems and shall not be used in any other way without the written permission of an appointed representative of TestAmerica. The procedure for control of distribution is incorporated by reference to SOP PE-QAD-010 – Document Control and/or PE-QAD-014 – Creation and Maintenance of SOPs.

The order of precedence in the event of a conflict between policies is outlined in Section 5.3 of this Quality Assurance Manual.

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Figure 3-1.

Example - Format for a QA/QC Policy Memorandum

Corporate (or Laboratory) QA/QC Policy Memorandum # _____

Effective Date: _____ Expiration Date: When Appropriate QAM Section is Revised

Corporate: *(Only needed for Corporate Memorandum – Delete if Laboratory)*

_____	_____
COO Date	Vice-President, QA and EHS Date

Local:

_____	_____
Laboratory Director Approval Date	Quality Assurance Approval Date
_____	_____
Operations Manager Approval Date	Department Managers (if needed) Date

1. **Purpose**

2. **Procedure**

3. **Attachments**

4. **References/Cross References**

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SECTION 4

ORGANIZATION AND MANAGEMENT
(NELAC 5.4.1)

4.1 OVERVIEW

TestAmerica Phoenix is part of a national network of laboratories known as TestAmerica. This Quality Assurance Manual (QAM) is applicable to the TestAmerica Phoenix laboratory only.

TestAmerica Phoenix
4645 East Cotton Center Boulevard, Building 3, Suite 189
Phoenix, Arizona 85040
EPA ID number: AZ00986

The Corporate organization chart can be found in Figure 4-1 and the laboratory's organization chart can be found in Appendix 2. The locations of other TestAmerica labs are as follows:

TestAmerica Anchorage
TestAmerica Austin
TestAmerica Buffalo
TestAmerica Burlington
TestAmerica Cedar Falls
TestAmerica Chicago
TestAmerica Connecticut
TestAmerica Corpus Christi
TestAmerica Dayton
TestAmerica Denver
TestAmerica Edison
TestAmerica Honolulu
TestAmerica Houston
TestAmerica Irvine
TestAmerica King of Prussia
TestAmerica Knoxville
TestAmerica Los Angeles
TestAmerica Mobile
TestAmerica Morgan Hill
TestAmerica Nashville
TestAmerica North Canton
TestAmerica Ontario
TestAmerica Orlando
TestAmerica Pensacola
TestAmerica Pittsburgh
TestAmerica Portland
TestAmerica Richland
TestAmerica San Francisco
TestAmerica Savannah
TestAmerica Seattle

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TestAmerica Spokane
TestAmerica St. Louis
TestAmerica Tacoma
TestAmerica Tallahassee
TestAmerica Tampa
TestAmerica Valparaiso
TestAmerica Watertown
TestAmerica West Sacramento
TestAmerica Westfield

4.2 ROLES AND RESPONSIBILITIES

In order for the Quality Assurance Program to function properly, all members of the staff must clearly understand and meet their individual responsibilities as they relate to the quality program. The following descriptions define each role in its relationship to the Quality Assurance Program. More extensive job descriptions are maintained by TestAmerica Phoenix's Human Resources Department.

4.2.1 Quality Assurance Program

The responsibility for quality lies with every employee of TestAmerica Phoenix. All employees have access to the QAM and are responsible for knowing the content of this manual and upholding the standards therein. Each person carries out his/her daily tasks in a manner consistent with the goals and in accordance with the procedures in this manual and the laboratory's SOPs.

4.2.2 President/Chief Executive Officer (CEO)

The President/CEO is a member of the Board of Directors and is ultimately responsible for the quality and performance of all TestAmerica facilities. The President/CEO establishes the overall quality standard and data integrity program for the Analytical Division, providing the necessary leadership and resources to assure that the standard and integrity program are met.

4.2.3 Chief Operating Officer (COO)

The COO serves as the ranking executives for all respective analytical laboratory operational functions and report to the President/CEO of the Analytical Division. The COO is responsible for the daily management of all analytical laboratories, long-term planning and development of technical policies and management plans. The COO ensures the attainment of corporate objectives through the selection, development, motivation, and evaluation of top management personnel. The COO approves all operating budgets and capital expenditures. The COO signs-off on the final QAM template that contains company policies for implementing the Quality Program.

4.2.4 General Manager (GM)

Each GM reports directly to the COO. Each GM has full responsibility for the overall administrative and operational management of their respective laboratories. The GM's responsibilities include allocation of personnel and resources, long-term planning, setting goals, and achieving the financial, business, and quality objectives of TestAmerica. The GM ensures

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timely compliance with corporate management directives, policies, and management systems reviews. The GM is also responsible for restricting any laboratory from performing analyses that cannot be consistently and successfully performed to meet the standards set forth in this manual.

4.2.5 Vice President of Client and Technical Services

The Vice President (VP) of Client and Technical Services reports directly to the President/CEO and is responsible for offerings to clients including quality assurance, environmental health and safety, risk management, technical assistance, legal compliance and contract administration. The VP of Client and Technical Services provides support and direction to the Executive Director and Directors of these areas, and supports the COO in decisions regarding long term planning, resource allocation and capital expenditures.

4.2.6 Executive Director of Quality and Environmental Health and Safety (QA/EHS)

The Executive Director of QA/EHS reports to the VP of Client and Technical Services. With the aid of the Senior Management Team, Laboratory Director/ Managers, Quality Directors, EHS Directors, QA Managers and EHS Coordinators, the Executive Director-QA/EHS has the responsibility for the establishment, general overview and Corporate maintenance of the Quality Assurance and Environmental, Health and Safety Program within TestAmerica. Additional responsibilities include:

- Review of QA/QC aspects of Corporate SOPs, national projects and expansions or changes in services.
- Coordination/preparation of the Corporate QAM Template that is used by each laboratory to prepare its own laboratory-specific QAM.
- Maintenance of Corporate Policies, Quality Memorandums and SOPs. Maintenance of data investigation records that are reported to Corporate Management.
- Work with various organizations outside of TestAmerica to further the development of quality standards and represent TestAmerica at various trade meetings.
- Preparation of a monthly report that includes quality metrics across the Analytical Division and a summary of any quality related initiatives and issues.
- With the assistance of the Corporate Senior Management Teams and the EHS Directors, development and implementation of the TestAmerica Environmental, Health and Safety Program.

4.2.7 Quality Directors (Corporate)

The Quality Directors report to the Executive Director-QA/EHS. Together with the Executive Director-QA/EHS, the Quality Directors have the responsibility for the establishment, general overview and maintenance of the Analytical Division's Quality Assurance Program within TestAmerica. The Quality Directors are responsible for:

- Oversight of the QA/QC programs within each laboratory. This includes a final review of each laboratory-specific QAM and receipt of each laboratory's QA monthly report.

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- Working with management to develop a plan of correction when a laboratory's quality system is determined to be inadequate.
- Review of QA/QC aspects of national projects.
- Assistance with certification activities.
- Providing assistance as needed in the selection of Quality Assurance Managers and reviewing their effectiveness.

4.2.8 Ethics and Compliance Officers (ECOs)

TestAmerica has designated two senior members of the Corporate staff to fulfill the role of Ethics and Compliance Officer (ECO) – VP-Client and Technical Services and the Executive Director-QA/EHS. Each ECO acts as a back-up to the other ECO and both are involved when data investigations occur. Each ECO has a direct line of communication to the entire senior Corporate and lab management staff.

The ECOs ensure that the organization distributes the data integrity and ethical practices policies to all employees and ensures annual trainings and orientation of new hires to the ethics program and its policies. The ECO is responsible for establishing a mechanism to foster employee reporting of incidents of illegal, unethical, or improper practices in a safe and confidential environment.

The ECOs monitor and audit procedures to determine compliance with policies and to make recommendations for policy enhancements to the CEOs, COO, Laboratory Director/Manager or other appropriate individuals within the laboratory. The ECO will assist the laboratory QA Manager in the coordination of internal auditing of ethical policy related activities and processes within the laboratory, in conjunction with the laboratories regular internal auditing function.

The ECOs will also participate in investigations of alleged violations of policies and work with the appropriate internal departments to investigate misconduct, remedy the situation, and prevent recurrence of any such activity.

4.2.9 Director of Technical Services

The Director of Technical Services is responsible for establishing, implementing and communicating TestAmerica's Technical Policies, SOPs, and Manuals. Other responsibilities include conducting technical assessments as required, acting as a technical resource in national contracts review, coordinating new technologies, establishing best practices, advising staff on technology advances, innovations, and applications.

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4.2.10 Chief Information Officer (CIO)

The CIO is responsible for establishing, implementing and communicating TestAmerica's Information Technology (IT) Policies, SOPs and Manuals. Other responsibilities include coordinating new technologies, development of electronic communication tools such as TestAmerica's intranet and internet sites, ensuring data security and documentation of software, ensuring compliance with the NELAC standard, and assistance in establishing, updating, and maintaining Laboratory Information Management Systems (LIMS) at the various TestAmerica facilities.

4.2.11 Environmental Health and Safety Directors (EHSDs) (Corporate)

The EHSDs report directly to the Executive Director-QA/EHS. The EHSDs are responsible for the development and implementation of the TestAmerica Environmental, Health and Safety program. Responsibilities include:

- Consolidation and tracking all safety and health-related information and reports for the company, and managing compliance activities for TestAmerica locations.
- Coordination/preparation of the corporate Environmental, Health and Safety Manual Template that is used by each laboratory to prepare its own laboratory-specific Safety Manual/ CHP.
- Development and execution of the company Environmental Health and Safety Internal Audit program.
- Preparation of information and training materials for laboratory EHS Coordinators.
- Assistance in the internal and external coordination of employee exposure and medical monitoring programs to insure compliance with applicable safety and health regulations.
- Serving as Department of Transportation (D.O.T.) focal point and providing technical assistance to location management.
- Serving as Hazardous Waste Management main contact and providing technical assistance to location management.

4.2.12 Laboratory Director

TestAmerica Phoenix's Laboratory Director is responsible for the overall quality, safety, financial, technical, human resource and service performance of the whole laboratory and reports to their respective GM. The Laboratory Director provides the resources necessary to implement and maintain an effective and comprehensive Quality Assurance and Data Integrity Program. The Laboratory Director who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full time staff member who meets the minimum qualifications of the Laboratory Manager to temporally perform the Laboratory Manager function. Also, if this absence exceeds 65 consecutive calendar days, the primary NELAP accrediting authority must be notified in writing.

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Specific responsibilities include, but are not limited to:

- Ensures that all analysts and Department Managers have the appropriate education and training to properly carry out the duties assigned to them and ensures that this training has been documented.
- Ensures that personnel are free from any commercial, financial and other undue pressures which might adversely affect the quality of their work.
- Ensures TestAmerica's human resource policies are adhered to and maintained.
- Ensures that sufficient numbers of qualified personnel are employed to supervise and perform the work of the laboratory.
- Ensures that appropriate corrective actions are taken to address analyses identified as requiring such actions by internal and external performance or procedural audits. Procedures that do not meet the standards set forth in the QAM or laboratory SOPs may be temporarily suspended by the Laboratory Director.
- Reviews and approves all SOPs prior to their implementation and ensures all approved SOPs are implemented and adhered to.
- Pursues and maintains appropriate laboratory certification and contract approvals. Supports ISO 17025 requirements.
- Ensures client specific reporting and quality control requirements are met.
- Captains the management team, consisting of the QA Manager, the Operations Manager, and the Department Manager(s) as direct reports.

4.2.13 Quality Assurance (QA) Manager

The QA Manager has responsibility and authority to ensure the continuous implementation of the quality system based on ISO 17025.

The QA Manager reports directly to the Laboratory Director and has access to Corporate QA for advice and resources. This position is able to evaluate data objectively and perform assessments without outside (i.e., managerial) influence. Corporate QA may be used as a resource in dealing with regulatory requirements, certifications and other quality assurance related items. The QA Manager directs the activities of the QA officers to accomplish specific responsibilities, which include, but are not limited to:

- Having functions independent from laboratory operations for which he/she has quality assurance oversight.
- Maintaining and updating the QAM.
- Monitoring and evaluating laboratory certifications; scheduling proficiency testing samples.
- Monitoring and communicating regulatory changes that may affect the laboratory to management.
- Training and advising the laboratory staff on quality assurance/quality control procedures that are pertinent to their daily activities.
- Having a general knowledge of the analytical test methods for which data audit/review is performed (and/or having the means of getting this information when needed).

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- Arranging for or conducting internal audits on quality systems and the technical operation.
- The laboratory QA Manager will maintain records of all ethics-related training, including the type and proof of attendance.
- Maintain, improve, and evaluate the corrective action database and the corrective and preventive action systems.
- Notifying laboratory management of deficiencies in the quality system and ensuring corrective action is taken. Procedures that do not meet the standards set forth in the QAM or laboratory SOPs are temporarily suspended following the procedures outlined in Section 13.
- Monitoring standards of performance in quality control and quality assurance.
- Coordinating of document control of SOPs, MDLs, control limits, and miscellaneous forms and information.
- Review a percentage of all final data reports for internal consistency. Review of Chain of Custody (COC), correspondence with the analytical request, batch QC status, completeness of any corrective action statements, 5% of calculations, format, holding time, sensibility and completeness of the project file contents.
- Review of external audit reports and data validation requests.
- Follow-up with audits to ensure client QAPP requirements are met.
- Establishment of reporting schedule and preparation of various quality reports for the Laboratory Director, clients and/or Corporate QA.
- Development of suggestions and recommendations to improve quality systems.
- Research of current state and federal requirements and guidelines.
- Captains the QA team to enable communication and to distribute duties and responsibilities.

4.2.14 Operations Manager

The Operations Manager manages and directs the analytical production sections of the laboratory. He/She reports directly to the Laboratory Director. He/She assists the Laboratory Director and Department Manager(s) in determining the most efficient instrument utilization. More specifically, he/she:

- Evaluates the level of internal/external non-conformances for all departments.
- Continuously evaluates production capacity and improves capacity utilization.
- Continuously evaluates turnaround time and addresses any problems that may hinder meeting the required and committed turnaround time from the various departments.
- Develops and improves the training of all analysts in cooperation with the Laboratory Director, the Department Manager(s) and QA Manager and in compliance with regulatory requirements.
- Works with the Preventive Maintenance Coordinator to ensure that scheduled instrument maintenance is completed.
- Is responsible for efficient utilization of supplies.
- Constantly monitors and modifies the processing of samples through the departments.

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- Fully supports the quality system and, if called upon in the absence of the QA Manager, serves as his substitute in the interim.

4.2.15 Environmental Health and Safety Coordinator

The Environmental Health and Safety Coordinator reports directly to the Laboratory Director and has access to the Corporate Environmental Health and Safety Director. The Environmental Health and Safety Coordinator may also act as the Hazardous Waste Manager or delegate the duties to an authorized and properly trained employee.

- Ensuring compliance with air permits.
- Conduct ongoing, necessary safety training and conduct new employee safety orientation.
- Assist in developing and maintaining the Chemical Hygiene/Safety Manual.
- Administer dispersal of all Material Safety Data Sheet (MSDS) information.
- Perform regular chemical hygiene and housekeeping instruction.
- Give instruction on proper labeling and practice.
- Serve as chairman of the laboratory safety committee.
- Provide and train personnel on protective equipment.
- Oversee the inspection and maintenance of general safety equipment – fire extinguishers, safety showers, eyewash fountains, etc. and ensure prompt repairs as needed.
- Supervise and schedule fire drills and emergency evacuation drills.
- Determine what initial and subsequent exposure monitoring, if necessary to determine potential employee exposure to chemicals used in the laboratory.
- When determined necessary, conduct exposure monitoring assessments.
- Determine when a complaint of possible over-exposure is “reasonable” and should be referred for medical consultation.
- Assist in the internal and external coordination of the medical consultation/monitoring program conducted by TestAmerica’s medical consultants.

4.2.16 Hazardous Waste Coordinator

The Hazardous Waste Coordinator reports directly to the Laboratory Director. The duties consist of:

- Staying current with the hazardous waste regulations.
- Continuing training on hazardous waste issues.
- Reviewing and updating annually the Hazardous Waste Contingency Plan in the Environmental Health & Safety Manual.
- Auditing the staff with regard to compliance with the Hazardous Waste Contingency Plan.
- Contacting the hazardous waste subcontractors for review of procedures and opportunities for minimization of waste.

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- Ensure proper collection and disposal of all hazardous waste.

4.2.17 Department Managers

The Department Managers report directly to the Laboratory Director. Each one is responsible to:

- Ensure that analysts in their department adhere to applicable SOPs and the QA Manual. They perform frequent SOP and QA Manual review to determine if analysts are in compliance and if new, modified, and optimized measures are feasible and should be added to these documents.
- With regard to analysts, participates in the selection, training (as documented in Section 8.1), development of performance objectives and standards of performance, appraisal (measurement of objectives), scheduling, counseling, discipline, and motivation of analysts and documents these activities in accordance with systems developed by the QA and Personnel Departments. They evaluate staffing sufficiency and overtime needs. Training consists of familiarization with SOP, QC, Safety, and computer systems.
- Encourage the development of analysts to become cross-trained in various methods and/or operate multiple instruments efficiently while performing maintenance and documentation, self-supervise, and function as a department team.
- Provide guidance to analysts in resolving problems encountered daily during sample prep/analysis in conjunction with the Operations Manager, and/or QA Manager. Each is responsible for 100% of the data review and documentation, non-conformance and CAR issues, the timely and accurate completion of performance evaluation samples and MDLs, for his department.
- Ensure all logbooks are maintained, current, and properly labeled or archived.
- Report all non-conformance conditions to the QA Manager, Operations Manager, and/or Laboratory Director.
- Ensure that preventive maintenance is performed on instrumentation as detailed in the QA Manual or SOPs. He/She is responsible for developing and implementing a system for preventive maintenance, troubleshooting, and repairing or arranging for repair of instruments.
- Maintain adequate and valid inventory of reagents, standards, spare parts, and other relevant resources required to perform daily analysis.
- Achieve optimum turnaround time on analyses and compliance with holding times.
- Conduct efficiency and cost control evaluations on an ongoing basis to determine optimization of labor, supplies, overtime, first-run yield, capacity (designed vs. demonstrated), second- and third-generation production techniques/instruments, and long-term needs for budgetary planning.
- Develop, implement, and enhance calibration programs.
- Provide written responses to external and internal audit issues.

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4.2.18 Laboratory Analysts

Laboratory analysts are responsible for conducting analysis and performing all tasks assigned to them by the group leader or Department Manager. The responsibilities of the analysts are listed below:

- Perform analyses by adhering to analytical and quality control protocols prescribed by current SOPs, this QA Manual, and project-specific plans honestly, accurately, timely, safely, and in the most cost-effective manner.
- Document standard and sample preparation, instrument calibration and maintenance, data calculations, sample matrix effects, and any observed non-conformance on worklists, benchsheets, lab notebooks and/or the Non-Conformance Database.
- Report all non-conformance situations, instrument problems, matrix problems and QC failures, which might affect the reliability of the data, to their Department Manager, the Operations Manager, and/or the QA Manager or member of QA staff.
- Perform 100% review of the data generated prior to entering and submitting for secondary level review.
- Suggest method improvements to their Department Manager, the Operations Manager, and the QA Manager. These improvements, if approved, will be incorporated. Ideas for the optimum performance of their assigned area, for example, through the proper cleaning and maintenance of the assigned instruments and equipment, are encouraged.
- Work cohesively as a team in their department to achieve the goals of accurate results, optimum turnaround time, cost effectiveness, cleanliness, complete documentation, and personal knowledge of environmental analysis.

4.2.19 Sample Receiving Manager

In addition to the general Department Manager duties (4.2.23), the Sample Receiving Manager reports to the Client Services Manager. He/She is responsible for ensuring the timely and correct shipment of sample containers, including proper preservatives and instructions, to clients. He/She maintains accurate records of sample container shipments. The responsibilities are outlined below:

- Direct the logging of incoming samples into the LIMS.
- Ensure the verification of data entry from login.
- Manages facility maintenance.
- Supervises the organized storage and appropriate climate control of samples.
- Supervises the disposal of samples in accordance with the Waste Disposal SOP, the Hazardous Waste Contingency Plan in the Chemical Hygiene/Safety Manual, and the U. S. Department of Agriculture requirements.

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4.2.20 Client Services Manager (CSM)

The Client Services Manager reports to the Laboratory Director and serves as the interface between the laboratory's technical departments and the laboratory's clients. The staff consists of the Project Management team. With the overall goal of total client satisfaction, the functions of this position are outlined below:

- Technical training and growth of the Project Management team.
- Technical liaison for the Project Management team.
- Human resource management of the Project Management team.
- Responsible to ensure that clients receive the proper sampling supplies.
- Accountable for response to client inquiries concerning sample status.
- Responsible for assistance to clients regarding the resolution of problems concerning COC.
- Ensuring that client specifications, when known, are met by communicating project and quality assurance requirements to the laboratory.
- Notifying the Department Managers of incoming projects and sample delivery schedules.
- Accountable to clients for communicating sample progress in daily status meeting with agreed-upon due dates.
- Responsible for discussing with client any project-related problems, resolving service issues, and coordinating technical details with the laboratory staff.
- Responsible for staff familiarization with specific quotes, sample log-in review, and final report completeness.
- Monitor the status of all data package projects in-house to ensure timely and accurate delivery of reports.
- Inform clients of data package-related problems and resolve service issues.
- Coordinate requests for sample containers and other services (data packages).

4.3 DEPUTIES

The following table defines who assumes the responsibilities of key personnel in their absence:

Key Personnel	Deputy
Laboratory Director	Operations Manager
QA Manager	Laboratory Director and/or QA Specialist
Operations Manager	Laboratory Director
VOA Department Manager	Operations Manager

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Key Personnel	Deputy
SVOA Department Manager	Operations Manager
Metals/Microbiological Department Manager	Operations Manager
Wet Chemistry Department Manager	Operations Manager
Extractions Department Manager	SVOA Department Manager
EHS Coordinator	QA Manager

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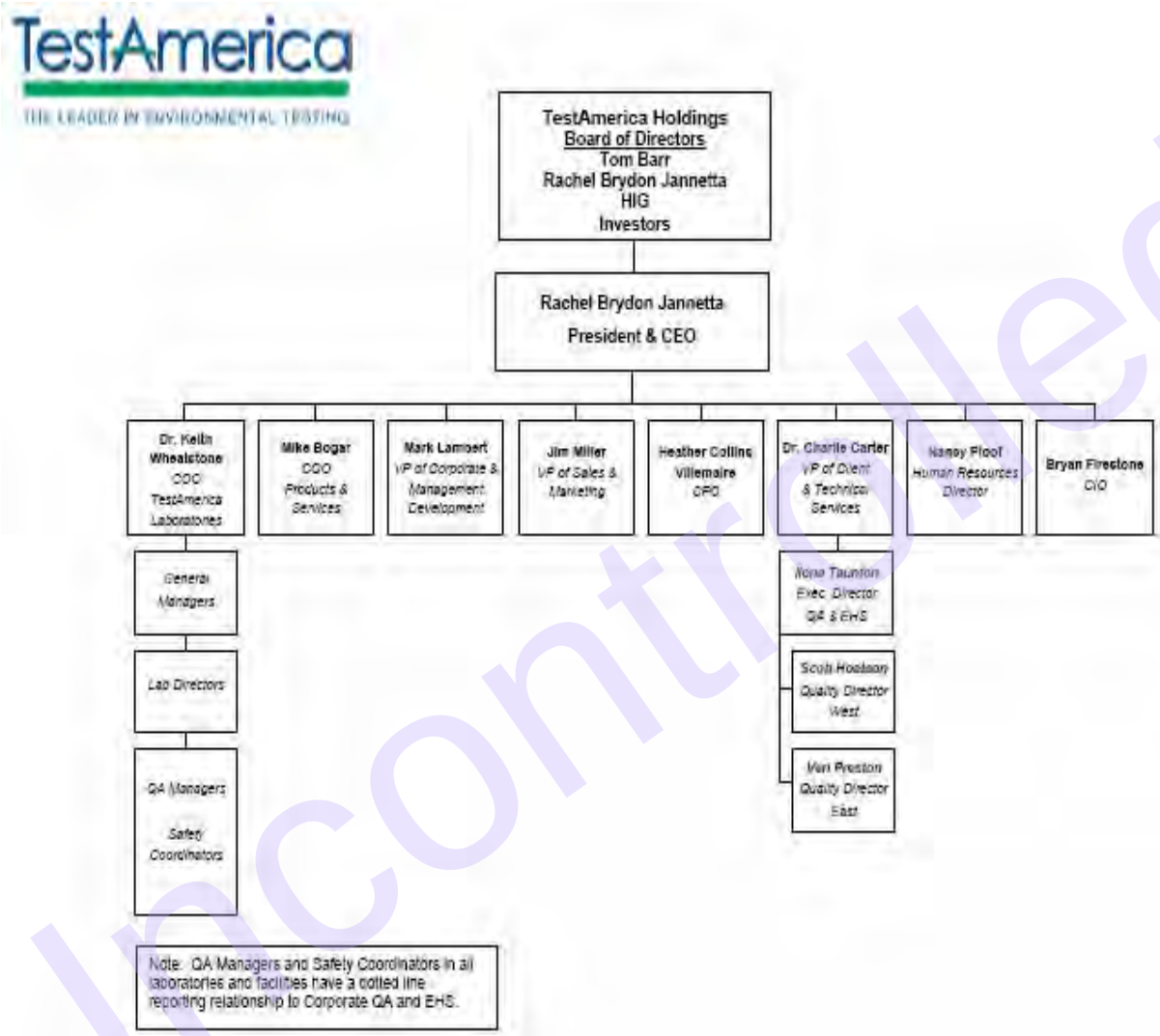
Figure 4-1.

Corporate Organization Chart



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SECTION 5

QUALITY SYSTEM
(NELAC 5.4.2)

5.1 QUALITY POLICY STATEMENT

The management of TestAmerica and TestAmerica Phoenix are committed to providing data of known quality to its clients by adhering to approved methodologies, regulatory requirements and the QA/QC protocols described in this manual.

In all aspects of the laboratory and business operations, management is dedicated in maintaining the highest ethical standards. An Ethics Policy sign-off can be viewed in Appendix 1. Training on ethical and legal responsibilities is provided annually and each employee signs off annually on the policy as a condition of employment.

It is TestAmerica's Policy to continually improve systems and provide support to quality improvement efforts in laboratory, administrative and managerial activities. The company recognizes that the implementation of a quality assurance program requires management's commitment and support as well as the involvement of the entire staff.

TestAmerica Phoenix strives to provide clients with the highest level of professionalism and the best service practices in the industry.

Every staff member at TestAmerica Phoenix plays an integral part in quality assurance and is held responsible and accountable for the quality of their work. It is, therefore, required that all laboratory personnel are trained and agree to comply with applicable procedures and requirements established by this document.

5.2 ETHICS AND DATA INTEGRITY

TestAmerica is committed to ensuring the integrity of its data and meeting the quality needs of its clients. The 7 elements of TestAmerica's Ethics and Data Integrity Program include:

- An Ethics Policy (Policy No. CA-L-P-001) and employee ethics statements (Appendix 1).
- An Ethics and Compliance Officer (ECO).
- A training program.
- Self-governance through disciplinary action for violations.
- A confidential mechanism for anonymously reporting alleged misconduct and a means for conducting internal investigations of all alleged misconduct. (SOP No. CA-L-S-001).
- Procedures and guidance for recalling data if necessary (SOP No. CA-L-S-001).
- An effective external and internal monitoring system that includes procedures for internal audits (Section 16).

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As an American Council of Independent Laboratories (ACIL) member, all TestAmerica laboratories adhere to the following ACIL Code of Ethics:

- Produce results, which are accurate and include QA/QC information that meets client pre-defined Data Quality Objectives (DQOs).
- Present services in a confidential, honest and forthright manner.
- Provide employees with guidelines and an understanding of the ethical and quality standards of our industry.
- Operate our facilities in a manner that protects the environment and the health and safety of employees and the public.
- Obey all pertinent federal, state and local laws and regulations and encourage other members of our industry to do the same.
- Educate clients as the extent and kinds of services available.
- Assert competency only for work for which adequate personnel and equipment are available and for which adequate preparation has been made.
- Promote the status of environmental laboratories, their employees, and the value of services rendered by them.

5.3 QUALITY SYSTEM SUPPORTING DOCUMENTATION

The laboratory's Quality System is communicated through a variety of documents prepared by the laboratory and company management:

- Quality Assurance Manual (QAM) Template.
- Quality Assurance Manual – Each laboratory has a lab specific quality assurance manual.
- Corporate SOPs and Policies - Corporate SOPs and Policies are developed for use by all relevant laboratories. They are incorporated into the laboratory's normal SOP distribution, training and tracking system. Corporate SOPs may be general or technical.
- Work Instructions - A subset of procedural steps, tasks or forms associated with an operation of a management system (e.g., checklists, preformatted bench sheets, forms).
- Laboratory SOPs – General and Technical.
- Corporate TestAmerica QA/QC Policy Memorandums (Refer to Section 3.4).
- Laboratory QA/QC Policy Memorandums (Refer to Section 3.4).

5.3.1 Order of Precedence

In the event of a conflict or discrepancy between policies, the order of precedence is as follows:

- TestAmerica QA/QC Policy Memorandum - Corporate
- Laboratory QA/QC Policy Memorandum
- Quality Assurance Manual
- Corporate SOPs and Policies
- Laboratory SOPs and Policies

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- Other (Work Instructions (WI), memos, flow charts, etc.)

5.4 QA/QC OBJECTIVES FOR THE MEASUREMENT OF DATA

Quality Assurance (QA) and Quality Control (QC) are activities undertaken to achieve the goal of producing data that accurately characterize the sites or materials that have been sampled. Quality Assurance is generally understood to be more comprehensive than Quality Control. Quality Assurance can be defined as the integrated system of activities that ensures that a product or service meets defined standards.

Quality Control is generally understood to be limited to the analyses of samples and to be synonymous with the term *"analytical quality control"*. QC refers to the routine application of statistically based procedures to evaluate and control the accuracy of results from analytical measurements. The QC program includes procedures for estimating and controlling precision and bias and for determining reporting limits.

Request for Proposals (RFPs) and Quality Assurance Project Plans (QAPP) provide a mechanism for the client and the laboratory to discuss the data quality objectives in order to ensure that analytical services closely correspond to client needs. The client is responsible for developing the QAPP. In order to ensure the ability of the laboratory to meet the Data Quality Objectives (DQOs) specified in the QAPP, clients are advised to allow time for the laboratory to review the QAPP before being finalized. Additionally, the laboratory will provide support to the client for developing the sections of the QAPP that concern laboratory activities.

Historically, laboratories have described their QC objectives in terms of precision, accuracy, representativeness, comparability, completeness, selectivity and sensitivity (PARCCSS).

5.4.1 Precision

The laboratory objective for precision is to meet the performance for precision demonstrated for the methods on similar samples and to meet data quality objectives of the EPA and/or other regulatory programs. Precision is defined as the degree of reproducibility of measurements under a given set of analytical conditions (exclusive of field sampling variability). Precision is documented on the basis of replicate analysis, usually duplicate or matrix spike (MS) duplicate samples. The calculation of precision is described in Section 25.

5.4.2 Accuracy

The laboratory objective for accuracy is to meet the performance for accuracy demonstrated for the methods on similar samples and to meet data quality objectives of the EPA and/or other regulatory programs. Accuracy is defined as the degree of bias in a measurement system. Accuracy may be documented through the use of laboratory control samples (LCS) and/or MS. A statement of accuracy is expressed as an interval of acceptance recovery about the mean recovery. The calculation of accuracy is described in Section 25.

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5.4.3 Representativeness

The laboratory objective for representativeness is to provide data which is representative of the sampled medium. Representativeness is defined as the degree to which data represent a characteristic of a population or set of samples and is a measurement of both analytical and field sampling precision. The representativeness of the analytical data is a function of the procedures used in procuring and processing the samples. The representativeness can be documented by the relative percent difference between separately procured, but otherwise identical samples or sample aliquots.

The representativeness of the data from the sampling sites depends on both the sampling procedures and the analytical procedures. The laboratory may provide guidance to the client regarding proper sampling and handling methods in order to assure the integrity of the samples.

5.4.4 Comparability

The comparability objective is to provide analytical data for which the accuracy, precision, representativeness and reporting limit statistics are similar to these quality indicators generated by other laboratories for similar samples, and data generated by the laboratory over time.

The comparability objective is documented by inter-laboratory studies carried out by regulatory agencies or carried out for specific projects or contracts, by comparison of periodically generated statements of accuracy, precision and reporting limits with those of other laboratories, and by the degree to which approval from the US EPA or other pertinent regulatory agencies is obtained for any procedure for which significant modifications have been made.

5.4.5 Completeness

The completeness objective for data is 90% (or as specified by a particular project), expressed as the ratio of the valid data to the total data over the course of the project. Data will be considered valid if they are adequate for their intended use. Data usability will be defined in a QAPP, project scope or regulatory requirement. Data validation is the process for reviewing data to determine its usability and completeness. If the completeness objective is not met, actions will be taken internally and with the data user to improve performance. This may take the form of an audit to evaluate the methodology and procedures as possible sources for the difficulty or may result in a recommendation to use a different method.

5.4.6 Selectivity

Selectivity is defined as: The capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances. Target analytes are separated from non-target constituents and subsequently identified/detected through one or more of the following, depending on the analytical method: extractions (separation), digestions (separation), interelement corrections (separation), use of matrix modifiers (separation), specific retention times (separation and identification), confirmations with different columns or detectors (separation and identification), specific wavelengths (identification), specific mass spectra (identification), specific electrodes (separation and identification), etc.

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5.4.7 Sensitivity

Sensitivity refers to the amount of analyte necessary to produce a detector response that can be reliably detected (Method Detection Limit) or quantified (Reporting Limit).

5.5 CRITERIA FOR QUALITY INDICATORS

The laboratory maintains tables of the Quality Control Limits that summarize the precision and accuracy acceptability limits for analyses performed at TestAmerica Phoenix. This summary includes an effective date, is updated each time new limits are generated and is located in the secure QA intra laboratory network. SOP PE-QAD-001 - Control Charts and Statistical Process Control explains how this process is carried out. Unless otherwise noted, limits within these tables are laboratory generated. Some acceptability limits are derived from US EPA methods when they are required. Where US EPA method limits are not required, TestAmerica Phoenix has developed limits from evaluation of data from similar matrices. Criteria for development of control limits is contained in Section 25.

5.6 STATISTICAL QUALITY CONTROL

Statistically-derived precision and accuracy limits are required by selected methods (such as SW-846) and programs [such as the Ohio Voluntary Action Plan (VAP)]. TestAmerica Phoenix routinely utilizes statistically-derived limits to evaluate method performance and determine when corrective action is appropriate. The analysts are instructed to use the current limits in the laboratory (dated and approved by the Department Manager and QA Manager) and entered into the Laboratory Information Management System (LIMS). The Quality Assurance department maintains an archive of all limits used within the laboratory (see SOP PE-QAD-001 Control Charts and Statistical Process Control). If a method defines the QC limits, the method limits are used.

If a method requires the generation of historical limits, the lab develops such limits from recent data in the QC database of the LIMS following the guidelines described in Section 25. All calculations and limits are documented and dated when approved and effective. On occasion, a client requests contract-specified limits for a specific project.

Surrogate recoveries are determined for a specific time period as defined above. The resulting ranges are entered in LIMS.

Current QC limits are entered and maintained in the LIMS analyte database. As sample results and the related QC are entered into LIMS, the sample QC values are compared with the limits in LIMS to determine if they are within the acceptable range. The analyst then evaluates if the sample needs to be rerun or re-extracted/rerun or if a comment should be added to the report explaining the reason for the QC outlier.

5.6.1 QC Charts

5.6.1.1 Selected methods (such as SW-846) and some programs require statistically derived precision and accuracy limits. TestAmerica - Phoenix routinely utilizes statistically derived limits to evaluate method performance and determine when corrective action is appropriate. The analysts are instructed to use the current limits in the laboratory (dated and approved by the

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Department Manager and QA Manager) and entered into the Laboratory Information Management System (LIMS). If a method defines the QC limits, the method limits are used.

5.6.1.2 If a method requires the generation of historical limits, the lab develops them from recent data in the QC database of LIMS following the guidelines described in Section 25. All calculations and limits are documented and dated when approved and effective. On occasion, a client requests contract-specified limits for a specific project.

5.6.1.3 Surrogate recoveries are determined for a specific time period as in 5.6.1.1. The resulting ranges are entered in LIMS.

5.6.1.4 Current QC limits are entered and maintained in the LIMS analyte database. As sample results and the related QC are entered into LIMS, the sample QC values are compared with the limits in LIMS to determine if they are within the acceptable range. The analyst then evaluates if the sample needs to be rerun or re-extracted/rerun or if a comment should be added to the report explaining the reason for the QC outlier.

5.6.1.5 As the QC limits are calculated or when lab personnel changes occur, QC charts are generated showing warning and control limits for the purpose of evaluating trends. The Quality Assurance Manager evaluates these to determine if adjustments need to be made or for corrective actions to methods. All findings are documented and kept on file. Refer to SOP PE-QAD-001 Control Charts and Statistical Process Control for more information.

5.7 QUALITY SYSTEM METRICS

In addition to the QC parameters discussed above, the entire Quality System is evaluated on a monthly basis through the use of specific metrics (refer to Section 17). These metrics are used to drive continuous improvement in the laboratory's Quality System.

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SECTION 6

DOCUMENT CONTROL
(NELAC 5.4.3)

6.1 OVERVIEW

The QA Department is responsible for the control of documents used in the laboratory to ensure that approved, up-to-date documents are in circulation and out-of-date (obsolete) documents are archived or destroyed. The following documents, at a minimum, must be controlled at each laboratory Facility:

- Laboratory Quality Assurance Manual
- Laboratory Standard Operating Procedures (SOP)
- Laboratory Policies
- Work Instructions and Forms
- Corporate Policies and Procedures distributed outside the intranet

The Corporate staff posts Corporate Manuals, SOPs, Policies, Work Instructions, White Papers and Training Materials on the company intranet site. These are collectively termed "Official Documents" and encompass the Policies and Procedures that all facilities are required to employ. These official documents are only considered controlled when they are read on the company intranet site. Printed copies are considered uncontrolled unless the laboratory physically distributes them as controlled documents. A detailed description of the procedure for issuing, authorizing, controlling, distributing, and archiving official documents is found in Corporate SOP No. CW-Q-S-001, Corporate Document Control and Archiving and PE-QAD-010 Document Control.

The laboratory QA Department also maintains access to various references and document sources integral to the operation of the laboratory. This includes reference methods and regulations. Instrument manuals (hard or electronic copies) are also maintained by the laboratory.

The laboratory maintains control of records for raw analytical data and supporting records such as audit reports and responses, logbooks, standard logs, training files, MDL studies, Proficiency Testing (PT) studies, certifications and related correspondence, and corrective action reports (CAR). Raw analytical data consists of bound logbooks, instrument printouts, any other notes, magnetic media, electronic data and final reports. Discussion on records control is described in Section 15.

The maintenance of purchasing data is discussed in Section 9.

The maintenance of sales and marketing contracts is discussed in Section 7.

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6.2 DOCUMENT APPROVAL AND ISSUE

The pertinent elements of a control system for each document include a unique name and number, the number of pages of the item, the effective date, revision number and the laboratory's name. The QA Department is responsible for the maintenance of the system and maintains the items in the QA Office and in Data Storage (see SOP PE-QAD-014 Creation and Maintenance of SOPs).

Controlled documents are authorized by the QA Department and other management. In order to develop a new document, a Department Manager submits an electronic draft to the QA Department for suggestions and approval before use. Upon approval, QA personnel add the identifying version information to the document and retains the official document on file. The official document is provided as needed to those using it. Controlled documents shall be available at all locations where the operational activity described in the document is performed (may include electronic access). Controlled documents are identified as such and records of their distribution are kept by the QA Department. Document control may be achieved by either electronic or hardcopy distribution.

The QA Department maintains a list of the official versions of controlled documents.

Quality System Policies and Procedures will be reviewed at a minimum of every year for drinking water and AIHA methods, and every two years for all other methods. The policies and procedures are revised as appropriate. Changes to documents occur when a procedural change warrants a revision of the document.

6.3 PROCEDURES FOR DOCUMENT CONTROL POLICY

For changes to the QA Manual:

The manual is reviewed annually by the Quality Assurance Manager and laboratory personnel to assure that it reflects current practices and meets the requirements of TestAmerica Phoenix's clients and regulators. Occasionally the manual may need changes in order to meet new or changing regulations and operations. The Quality Assurance Manager will review the changes in the normal course of business and incorporated changes into revised sections of the document. The updates will be reviewed by the Quality Assurance Manager, Laboratory Director, Department Managers, relevant operational staff and Corporate Quality Assurance (if a change is made to the corporate template) and then formally incorporated into the document in periodic updates. The QAM is based on a Corporate QAM template that is prepared and approved by the Executive Vice Presidents (EVP) of Operations and Corporate Quality Assurance. This template is reviewed annually by the EVPs of Operations, Corporate Quality Assurance and each laboratory. Necessary changes are coordinated by the Vice President of Quality Assurance and distributed to each laboratory for inclusion in the laboratory specific QA Manuals.

Refer to the current revision of corporate SOP CW-Q-S-001 - Corporate Document Control and Archiving for the corporate procedure. Uncontrolled copies must not be used within the laboratory. Previous revisions and back-up data are stored by the QA department. Electronic

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copies are stored on the Public server in the QA folder for the applicable revision. Electronic copies can be located in the following directory; \\Taplims\Admin\Departments\QA.

For changes to SOPs, refer to SOP No. CW-Q-S-002, Writing a Standard Operating Procedure (SOP).

Forms, worksheets, work instructions and information are organized by department in the QA office. There is a table of contents. Electronic versions are kept on a hard drive in the QA department. The procedure for the care of these documents is in SOP PE-QAD-010 - Document Control.

6.4 OBSOLETE DOCUMENTS

All invalid or obsolete documents are removed, or otherwise prevented from unintended use. The laboratory has specific procedures as described above to accomplish this. In general, obsolete documents are collected from employees according to distribution lists and are marked obsolete on the cover or destroyed. At least one copy of the obsolete document is archived as described in Section 15.

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SECTION 7

REVIEW OF WORK REQUEST

7.1 OVERVIEW

TestAmerica Phoenix has established procedures for the review of work requests and contracts, oral or written. The procedures include evaluation of the laboratory's capability and resources to meet the contract's requirements within the requested time period. All requirements, including the methods to be used, must be adequately defined, documented and understood. For many environmental sampling and analysis programs, testing design is site or program specific and does not necessarily "fit" into a standard laboratory service or product. It is TestAmerica's intent to provide both standard and customized environmental laboratory services to our clients.

A thorough review of technical and QC requirements contained in contracts is performed to ensure project success. The appropriateness of requested methods, and the lab's capability to perform them must be established. Projects, proposals and contracts are reviewed for adequately defined requirements and TestAmerica's capability to meet those requirements. Alternate test methods that are capable of meeting the clients' requirements may be proposed by the lab. A review of the lab's capability to analyze non-routine analytes is also part of this review process.

All projects, proposals and contracts are reviewed for the client's requirements in terms of compound lists, test methodology requested, sensitivity (detection and reporting levels), accuracy, and precision requirements (% Recovery and RPD). The reviewer ensures that the laboratory's test methods are suitable to achieve these regulatory and client requirements and that the laboratory holds the appropriate certifications and approvals to perform the work. The laboratory and any potential subcontract laboratories must be certified, as required, for all proposed tests.

The laboratory must determine if it has the necessary physical, personnel and information resources to meet the contract, and if the personnel have the expertise needed to perform the testing requested. Each proposal is checked for its impact on the capacity of the laboratory's equipment and personnel. As part of the review, the proposed turnaround time will be checked for feasibility.

Electronic or hard copy deliverable requirements are evaluated against the lab's capacity for production of the documentation.

If the laboratory cannot provide all services but intends to subcontract such services, whether to another TestAmerica facility or to an outside firm, this will be documented and discussed with the client prior to contract approval. (Refer to Section 8 for Subcontracting Procedures.)

The laboratory informs the client of the results of the review if it indicates any potential conflict, deficiency, lack of accreditation, or inability of the lab to complete the work satisfactorily. Any discrepancy between the client's requirements and TestAmerica's capability to meet those requirements is resolved in writing before acceptance of the contract. It is necessary that the contract be acceptable to both the laboratory and the client. Amendments initiated by the client and/or TestAmerica, are documented in writing.

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All contracts, QAPPs, Sampling and Analysis Plans (SAPs), contract amendments, and documented communications become part of the project record.

The review process is repeated when there are amendments to the original contract by the client, and the participating personnel are informed of the changes.

7.2 REVIEW SEQUENCE AND KEY PERSONNEL

Appropriate personnel will review the work request at each stage of evaluation.

For routine projects and other simple tasks, a review by the Project Manager (PM) is considered adequate. The PM confirms that the laboratory has any required certifications, that it can meet the clients' data quality and reporting requirements and that the lab has the capacity to meet the clients turn around needs. It is recommended that, where there is a sales person assigned to the account, an attempt should be made to contact that sales person to inform them of the incoming samples.

For new, complex or large projects, the proposed contract is given to the National Account Director, who will decide which lab will receive the work based on the scope of work and other requirements, including certification, testing methodology, and available capacity to perform the work. The contract review process is outlined in SOP No. CA-L-P-002**,** Contract Compliance Policy.

This review encompasses all facets of the operation. The scope of work is distributed to the appropriate personnel, as needed based on scope of contract, to evaluate all of the requirements shown above (not necessarily in the order below)

- Legal & Contracts Director
- General Manager
- The Client Services Manager
- The Laboratory Operations Manager
- Laboratory and/or Corporate Technical Directors
- Laboratory and/or Corporate Information Technology Managers/Directors
- Regional and/or National Account representatives
- Laboratory and/or Corporate Quality
- Laboratory and/or Corporate Environmental Health and Safety Managers/Directors
- The Laboratory Director reviews the formal laboratory quote and makes final acceptance for their facility.

The National Account Director, Legal Contracts Director, or local account representative then submits the final proposal to the client.

In the event that one of the above personnel is not available to review the contract, his or her back-up will fulfill the review requirements.

The Legal & Contracts Director maintains copies of all signed contracts**.** The Regional Account Executive or the Key Client Executive maintains the local copy of the contracts.

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7.3 DOCUMENTATION

Appropriate records are maintained for every contract or work request. All stages of the contract review process are documented and include records of any significant changes.

The contract will be distributed to and maintained by the Regional Account Executive or Key Client Executive. A copy of the contract and formal quote will be filed with the laboratory Project Manager.

Records are maintained of pertinent discussions with a client relating to the client's requirements or the results of the work during the period of execution of the contract. The Project Manager keeps a phone log of conversations with the client. Client correspondence and internal communications regarding projects are kept in the project file.

7.3.1 Project-Specific Quality Planning

Communication of contract specific technical and QC criteria is an essential activity in ensuring the success of site specific testing programs. To achieve this goal, TestAmerica Phoenix assigns a PM to each client. The PM is the first point of contact for the client. It is the PM's responsibility to ensure that project specific technical and QC requirements are effectively evaluated and communicated to the laboratory personnel before and during the project. QA department involvement may be needed to assist in the evaluation of custom QC requirements. See SOPs PE-PMD-001 Project Management Data Reporting, Validation and Distribution, PE-PMD-002 Project Management Communication and Documentation and PE-PMD-003 Project Management – Client/Project Set-up.

PM's are the direct client contact and they ensure resources are available to meet project requirements. Although PM's do not have direct reports or staff in production, they coordinate opportunities and work with laboratory management and supervisory staff to ensure available resources are sufficient to perform work for the client's project. Project management is positioned between the client and laboratory resources.

Prior to work on a new project, the dissemination of project information and/or project opening meetings may occur to discuss schedules and unique aspects of the project. Items to be discussed may include the project technical profile, turnaround times, holding times, methods, analyte lists, reporting limits, deliverables, sample hazards, or other special requirements. The PM introduces new projects to the laboratory staff through project kick-off meetings or to the supervisory staff during production meetings. These meetings provide direction to the laboratory staff in order to maximize production and client satisfaction, while maintaining quality. In addition, project notes may be associated with each sample batch as a reminder upon sample receipt and analytical processing.

During the project, any change that may occur within an active project is agreed upon between the client/regulatory agency and the PM/laboratory. These changes (e.g., use of a non-standard method or modification of a method) and approvals must be documented prior to implementation. Documentation pertains to any document, e.g., letter, e-mail, variance, contract addendum, which has been signed by both parties.

Such changes are also communicated to the laboratory during status meetings. Such changes are updated to the project notes and are introduced to the managers at these meetings. The laboratory

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staff is then introduced to the modified requirements via the PM or the individual laboratory Department Manager. After the modification is implemented into the laboratory process, documentation of the modification is made in the case narrative of the data report(s).

TestAmerica strongly encourages client visits to the laboratory and for formal/informal information sharing session with employees in order to effectively communicate ongoing client needs as well as project specific details for customized testing programs.

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SECTION 8

SUBCONTRACTING OF TESTS
(NELAC 5.4.5)

8.1 OVERVIEW

For the purpose of this quality manual, the phrase subcontract laboratory refers to a laboratory external to the corporate network. The phrase "work sharing" refers to internal transfers of samples between company laboratories. The term outsourcing refers to the act of subcontracting tests.

When contracting with our clients, the laboratory makes commitments regarding the services to be performed and the data quality for the results to be generated. When we must outsource testing for our clients because project scope, changes in laboratory capabilities, capacity or unforeseen circumstances, we must be assured that the subcontractors or work sharing laboratories understand the requirements and will meet the same commitments we have made to the client. Refer to the SOP on Subcontracting Procedures (CA-L-S-002) and the Work Sharing Process SOP (CA-C-S-001).

When outsourcing analytical services, the laboratory will assure, to the extent necessary, that the subcontract or work sharing laboratory maintains a program consistent with the requirements of this document, the requirements specified in NELAC, ISO 17025 and/or the client's Quality Assurance Project Plan (QAPP). All QC guidelines specific to the client's analytical program are transmitted to the subcontractor and agreed upon before sending the samples to the subcontract facility. Additionally, work requiring accreditation will be placed with an appropriately accredited laboratory. The laboratory performing the subcontracted work will be identified in the final report, as will non-NELAC accredited work where required.

Project Managers (PMs), Customer Service Managers (CSM), or Regional Account Executives (RAE) for the Export Lab are responsible for obtaining client approval prior to outsourcing any samples. The laboratory will advise the client of a subcontract or work sharing arrangement in writing and when possible approval from the client shall be retained in the project folder.

Note: In addition to the client, some regulating agencies, such as the US Army Corps of Engineers and the USDA, require notification prior to placing such work**.**

8.2 QUALIFYING AND MONITORING SUBCONTRACTORS

Whenever a PM, Regional Account Executive (RAE) or Customer Service Manager (CSM) becomes aware of a client requirement or laboratory need where samples must be outsourced to another laboratory, the other laboratory(s) shall be selected based on the following:

- The first priority is to attempt to place the work in a qualified network laboratory;
- Firms specified by the client for the task (documentation that a subcontractor was designated by the client must be maintained with the project file. This documentation can be as simple as placing a copy of an e-mail from the client in the project folder);
- Firms listed as pre-qualified and currently under a subcontract with the company (in JD Edwards): A listing of all approved subcontracting laboratories and supporting

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documentation is available on the TestAmerica intranet site).

- Firms identified in accordance with the company's Small Business Subcontracting program as small, women-owned, veteran-owned and/or minority-owned businesses;
- NELAC accredited laboratories.
- In addition, the firm must hold the appropriate certification to perform the work required.

All intra-company laboratories are pre-qualified for work sharing provided they hold the appropriate accreditations, can adhere to the project/program requirements, and the client approved sending samples to that laboratory. The client must provide acknowledgement that the samples can be sent to that facility (an e-mail is sufficient documentation or if acknowledgement is verbal, the date, time, and name of person providing acknowledgement must be documented). The originating laboratory is responsible for communicating all technical, quality, and deliverable requirements as well as other contract needs. Refer to SOP No. CA-C-S-001, Work Sharing Process.

When the potential sub-contract laboratory has not been previously approved, Account Executives or PMs may nominate a laboratory as a subcontractor based on need. The decision to nominate a laboratory must be approved by the Laboratory Director. The Laboratory Director requests that the QA Manager begin the process of approving the subcontract laboratory. The client must provide acknowledgement that the samples can be sent to that facility (an e-mail is sufficient documentation or if acknowledgement is verbal, the date, time, and name of person providing acknowledgement must be documented).

8.2.1 The QA Manager must ensure that the Subcontracting Approval Form (Figure 8-2) has been completed and have supporting documentation on file prior to initiation of any work. A letter or e-mail is sent to the lab requesting the following information:

8.2.1.1 If a lab is NELAC accredited,

8.2.1.1.1 Copy of necessary certifications verifying that the required approvals are current. Ensure that all needed analytes are included; some may not be accredit-able (if so, document). Certificate and scope of International Standard accreditation are required, when applicable.

8.2.1.1.2 Insurance Certificate. This is required by TestAmerica's Chief Financial Officer.

8.2.1.1.3 USDA soil permit if available**.

8.2.1.2 For Laboratories accredited by other agencies with an auditing program:

8.2.1.2.1 Copy of necessary certifications verifying that the required approvals are current. Ensure that all needed analytes are included; some may not be accredit-able (if so, document). Certificate and scope of International Standard accreditation are required, when applicable.

8.2.1.2.2 Insurance Certificate. This is required by TestAmerica's Chief Financial Officer.

8.2.1.2.3 USDA soil permit if available**.

8.2.1.2.4 Description of Ethics and Data Integrity Plan.

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8.2.1.2.5 The most recent 2 sets of full proficiency testing (PT) results relevant to the analyses of interest and any associated corrective action.

8.2.1.2.6 State Audit with Corrective Action Response.

8.2.1.2.7 Example final report to confirm format is compliant and provides the necessary information. (Minimally, it must be determined that Batch QC results are included in the laboratory reports and data is appropriately qualified).

8.2.1.2.8 A copy of raw data associated with the first project is requested for internal review. The raw data is reviewed by the QA Manager and the PM to ensure that the results meet the client's needs. If the QA Manager is unfamiliar with the analysis being performed, notify Corporate QA for guidance on the review (it may need to be sent elsewhere for evaluation). This requirement can be skipped if an on-site visit of the laboratory is planned. (This requirement is effective as of the effective date of this section. Laboratories worked with previously [minimum of 6 months] are grandfathered in.)

8.2.1.3 For laboratories performing tests that are unaccredited or accredited by an agency without an audit program:

8.2.1.3.1 A copy of their Quality Assurance Manual (controlled if possible). Ensure data quality limits for relevant methods are acceptable and that training procedures are adequate.

8.2.1.3.2 Copy of necessary certifications (if available) verifying that the required approvals are current. Ensure that all needed analytes are included; some may not be accredit-able (if so, document). Certificate and scope of International Standard accreditation are required, when applicable.

8.2.1.3.3 Insurance Certificate. This is required by TestAmerica's Chief Financial Officer.

8.2.1.3.4 USDA soil permit if available**.

8.2.1.3.5 Evidence of a current SOP per method. A copy of the first page and signature page of the SOP is acceptable. A table of contents including effective dates may also be acceptable. The SOP can be examined if an on-site audit is performed.

8.2.1.3.6 Description of Ethics and Data Integrity Plan.

8.2.1.3.7 The most recent 2 sets of full proficiency testing (PT) results relevant to the analyses of interest and any associated corrective action.

8.2.1.3.8 Example final report to confirm format is compliant and provides the necessary information. (Minimally, it must be determined that Batch QC results are included in the laboratory reports and data is appropriately qualified).

8.2.1.3.9 Statement of Qualification (SOQ) or summary list of Technical Staff and Qualifications – position, education and years of experience.

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8.2.1.3.10 A copy of raw data associated with the first project is requested for internal review. The raw data is reviewed by the QA Manager and the PM to ensure that the results meet the client's needs. If the QA Manager is unfamiliar with the analysis being performed, notify Corporate QA for guidance on the review (it may need to be sent elsewhere for evaluation). This requirement can be skipped if an on-site visit of the laboratory is planned. (This requirement is effective as of the effective date of this section. Laboratories worked with previously [minimum of 6 months] are grandfathered in.)

8.2.2 Once the information is received by the QA Manager, it is evaluated for acceptability and forwarded to Corporate Contracts for formal contracting with the laboratory. They will add the lab to the approved list on the intranet site along with the associate documentation and notify the finance group for JD Edwards.

****USDA permit is required if soils less than three feet deep from New York, North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Louisiana, Arkansas, Texas, Oklahoma, New Mexico, Arizona, California, Hawaii, or outside the continental U. S. are to be analyzed. These samples require special shipping measures; check with the EHS Department. It may be necessary to heat-treat the samples before shipping if the subcontract laboratory does not have a USDA permit; however, some analytes/tests may be irrelevant after heat treatment.**

8.2.3 The client will assume responsibility for the quality of the data generated from the use of a subcontractor they have requested the lab to use. The qualified subcontractors on the intranet site are known to meet minimal standards. The company does not certify laboratories. The subcontractor is on our approved list and can only be recommended to the extent that we would use them.

8.2.4 The status and performance of qualified subcontractors will be monitored periodically by the Corporate Contract Department. Any problems identified will be brought to Corporate QA attention.

- Complaints shall be investigated. Documentation of the complaint, investigation and corrective action will be maintained in the subcontractor's file on the intranet site. Complaints must be posted using the Vendor Performance Report (Form No. CW-F-WI-009)**.**
- Information must be updated on the intranet when new information is received from the subcontracted laboratories.
- Subcontractors in good standing will be retained on the intranet listing. The QA Manager will notify all network laboratories and Corporate QA and Corporate Contracts if any laboratory requires removal from the intranet site. This notification will be posted on the intranet site and e-mailed to all Lab Directors, QA Managers and Sales Directors.

8.3 OVERSIGHT AND REPORTING

The PM must request that the selected subcontractor be presented with a subcontract, if one is not already executed between the laboratory and the subcontractor. The subcontract must include terms which flow down the requirements of our clients, either in the subcontract itself or through the mechanism of work orders relating to individual projects. A standard subcontract and the Lab Subcontractor Vendor Package (posted on the intranet) can be used to accomplish

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this, and the Legal & Contracts Director can tailor the document or assist with negotiations, if needed. The PM (or RAE or CSM) responsible for the project must advise and obtain client consent to the subcontract as appropriate, and provide the scope of work to ensure that the proper requirements are made a part of the subcontract and are made known to the subcontractor.

Prior to sending samples to the subcontracted laboratory, the PM confirms their certification status to determine if it's current and scope-inclusive. The information is documented on a Subcontracted Sample Form (Figure 8-3) and the form is retained in the project folder. For network laboratories, certifications can be viewed on the company website.

The Sample Control department is responsible for ensuring compliance with QA requirements and applicable shipping regulations when shipping samples to a subcontracted laboratory.

All subcontracted samples must be accompanied by a Chain of Custody (COC). A copy of the original COC sent by the client must be included with all samples subbed within the network.

The PM will communicate with the subcontracted laboratory to monitor the status of the analyses, facilitate successful execution of the work and ensure the timeliness and completeness of the analytical report.

Non-NELAC accredited work must be identified in the subcontractor's report as appropriate. If NELAC accreditation is not required, the report does not need to include this information.

Reports submitted from subcontractor laboratories are not altered and are included in their original form in the final project report. This clearly identifies the data as being produced by a subcontractor facility. If subcontract laboratory data is incorporated into the laboratories EDD (i.e., imported), the report must explicitly indicate which lab produced the data for which methods and samples.

Note: The results submitted by a network work sharing laboratory may be transferred electronically and the results reported by the network work sharing lab are identified on the final report. The report must explicitly indicate which lab produced the data for which methods and samples. The final report must include a copy of the completed COC for all work sharing reports.

8.4 CONTINGENCY PLANNING

The Laboratory Director may waive the full qualification of a subcontractor process temporarily to meet emergency needs. In the event this provision is utilized, Corporate QA must be informed, and the QA Manager will be required to verify adequacy of proficiency scores and certifications. The laboratory must also request a copy of the raw data to support the analytical results for the first project submitted to the subcontract laboratory unless the laboratory has NELAC accreditation. The raw data is reviewed by the QA Manager and the PM to ensure that the results meet the client's needs. The QA Manager will request full documentation and qualify the subcontractor under the provisions above. The approval process should be completed within 30 calendar days of subcontracting.

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Figure 8-1.

Example - Client-Approved Subcontractor Form

Client Information:

Client Name & Account Number:_____

Client Contact: _____

Client Address: _____

_____

Project Information: **(Please choose all applicable.)**

- **Certification required:** ◻ **State** ◻ **NELAC** ◻ **A2LA** ◻ **Method**_____

  ◻ **Target compound**_____ ◻ **Other**_____

- **Required Turn around time (method provisional)**_____

Subcontractor's Information:

Subcontractor's Name: _____

Subcontractor's Contact: _____

Subcontractor's Email: _____

Subcontractor's Address: _____

_____

Subcontractor's Phone Number: _____

Analytical Test/Compound/Method to be subcontracted: _____

Certification Statement:

I hereby give **TestAmerica Phoenix** permission to use the above noted subcontractor for the above noted testing procedures/methods. I realize that the above subcontractor will be held liable for the validity of the above mentioned testing procedures/methods. All subcontractors shall meet the requirements as spelled out in project information and will follow all analytical holding times and turn around times for analytical reports. The subcontract laboratory, and not TestAmerica, will be held liable for liquidated damages for delays in subcontracted analytical reports and/or electronic data deliverables.

_____

Client Signature **Date**

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Figure 8-2.
Example - Subcontracting Laboratory Approval Form (Initial / Renewal)

SUBCONTRACTING LABORATORY APPROVAL

Reference: Section 8 – Quality Assurance Manual

Date: _____
Laboratory: _____

Address: _____
_____
Contact and e-mail address: _____
Phone: Direct _____ Fax _____

Requested Item[3]	Date Received	Reviewed/ Accepted	Date
1. Copy of State Certification[1]			
2. Insurance Certificate			
3. USDA Soil Permit			
4. Description of Ethics Program[3]			
5. QA Manual[3]			
6. Most Recent (and relevant) 2 Sets of WP/WS Reports with Corrective Action Response[1,3]			
7. State Audit with Corrective Action Response (or NELAC or A2LA Audit)[3]			
8. Sample Report[3]			
9. SOQ or Summary list of Technical Staff and Qualifications [3]			
10. SOPs for Methods to Be Loadshifted[2,3]			
11. For DoD Work: Statement that Lab quality system complies with QSM.			
12. For DoD Work: Approved by specific DoD Component laboratory approval process.			

1 - Required when emergency procedures are implemented.
2 - Some labs may not submit copies due to internal policies. In these cases, a copy of the first page and signature page of the SOP is acceptable. This requirement may also be fulfilled by supplying a table of SOPs with effective dates.
3 – If the laboratory has NELAC accreditation, Item #s 4 through 10 are not required.

On Site Audit Planned: YES NO If yes, Date Completed: _____ By Whom: _____

Comments:

Lab Acceptable for Subcontracting Work: YES NO Limitations: _____

QA Manager (Signature): _____ Date: _____
(Printed Name)

☐ Forwarded to Contract Coordinator, by: _____ Date: _____

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Figure 8-3.

Example - Subcontracted Sample Form

Date/Time: _____

Subcontracted Laboratory Information:

- Subcontractor's Name: _____
- Subcontractor Point of Contact: _____
- Subcontractor's Address: _____
- Subcontractor's Phone: _____
- Analyte/Method: _____
- Certified for State of Origin: _____
- NELAC Certified: Yes_____No_____
- A2LA (or ISO 17025) Certified: Yes_____No_____
- CLP-like Required: Yes_____No_____
  (Full doc required)
- Requested Sample Due Date: _____
  (Must be put on COC)

Project Manager: _____

Laboratory Sample # Range: _____
(Only of Subcontracted Samples)

Laboratory Project Number (Billing Control #): _____

All subcontracted samples are to be sent via bonded carrier and Priority Overnight. Please attach tracking number below and maintain these records in the project files.

PM Signature_____**Date**_____

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SECTION 9

PURCHASING SERVICES AND SUPPLIES
(NELAC 5.4.6)

9.1 OVERVIEW

Evaluation and selection of suppliers and vendors is performed, in part, on the basis of the quality of their products, their ability to meet the demand for their products on a continuous and short term basis, the overall quality of their services, their past history, and competitive pricing. This is achieved through evaluation of objective evidence of quality furnished by the supplier, which can include certificates of analysis, recommendations, and proof of historical compliance with similar programs for other clients. To ensure that quality critical consumables and equipment conform to specified requirements, all purchases from specific vendors are approved by a member of the Department Manager or management staff.

Capital expenditures are made in accordance with the Controlled Purchases Procedure, CW-F-S-004. Only one quote is required where the item being purchased is a sole source product, Examples of sole source capital expenditures are laboratory test equipment, client specified purchases and building leases. A minimum of two quotes is required where the opportunity exists to source from more than one vendor. All documentation related to the purchase of capital items will be maintained in the individual CapEx files located in Corporate Purchasing. Data will be held in accordance with the record retention policy.

TestAmerica will enter into formal contracts with vendors when it is advantageous to do so. Contracts will be signed in accordance with the Authorization Matrix Policy, CW-F-P-002. Examples of items that are purchased through vendor contracts are laboratory instruments, consumables, copiers and office supplies. Request for Proposals (RFP's) will be issued where more information is required from the potential vendors than just price. RFP's allow TestAmerica to determine if a vendor is capable of meeting requirements such as supplying all of the TestAmerica facilities, meeting required quality standards and adhering to necessary ethical and environmental standards. The RFP process also allows potential vendors to outline any additional capabilities they may offer.

Non-capital expenditure items are purchased through the requisition and approval process in JD Edwards or through other TestAmerica authorized methods (approved web-sites, purchasing cards). Labs have the ability to select from the approved vendors in JD Edwards.

9.2 GLASSWARE

Glassware used for volumetric measurements must be Class A or verified for accuracy according to laboratory procedure. Pyrex (or equivalent) glass should be used where possible. For safety purposes, thick-wall glassware should be used where available.

9.3 REAGENTS, STANDARDS & SUPPLIES

Chemical reagents, solvents, glassware, and general supplies are ordered as needed to maintain sufficient quantities on hand. Purchasing guidelines for equipment and reagents must meet with the requirements of the specific method and testing procedures for which they are

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being purchased. Solvents and acids are pre-tested in accordance with Corporate SOP on Solvent & Acid Lot Testing & Approval, SOP No. CA-Q-S-001.

9.3.1 Purchasing

The nature of the analytical laboratory demands that all material used in any of the procedures is of a known quality. The wide variety of materials and reagents available makes it advisable to specify recommendations for the name, brand, and grade of materials to be used in any determination. This information is contained in the method SOP. The analyst should complete the Material Request Sheet (Figure 9-1 – Fisher Consignment form) when requesting reagents, standards, or supplies. The respective Department Manager checks the item out of the on-site consignment system that contains items approved for laboratory use.

For items not in Fisher Consignment, the Department Manager prepares an order in the JD Edwards system. The order is then approved by the Laboratory Director or the Operations Manager.

9.3.2 Receiving

It is the responsibility of the warehouseman to receive the shipment. It is the responsibility of the warehouseman to date the material when received and compare the information on the label or packaging to the original order to ensure that the purchase meets the quality level specified. The laboratory department receiving the item confirms that the quality of the item received meets level specified. Material Safety Data Sheets (MSDSs) are kept in the analytical department or in the Element LIMS and online through the Company's intranet website. Anyone may review these for relevant information on the safe handling and emergency precautions of on-site chemicals.

9.3.3 Specifications

There are many different grades of analytical reagents available to the analyst. All methods in use in the laboratory specify the grade of reagent that must be used in the procedure. If the quality of the reagent is not specified, it may be assumed that it is not significant in that procedure and, therefore, any grade reagent may be used. It is the responsibility of the analyst to check the procedure carefully for the suitability of grade of reagent.

Chemicals must not be used past the manufacturer's expiration date and must not be used past the expiration time noted in a method SOP. If dates are not provided, the laboratory may contact the manufacturer to determine an expiration date.

The laboratory assumes a five year expiration date on inorganic dry chemicals unless noted otherwise by the manufacturer or by the reference source method.

- An expiration date can not be extended if the dry chemical is discolored or appears otherwise physically degraded, the dry chemical must be discarded.

- Expiration dates can be extended if the dry chemical is found to be satisfactory based on acceptable performance of quality control samples (Continuing Calibration Verification (CCV), Blanks, Laboratory Control Sample (LCS), etc.).

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- If the dry chemical is used for the preparation of standards, the expiration dates can be extended 6 months if the dry chemical is compared to an unexpired independent source in performing the method and the performance of the dry chemical is found to be satisfactory. The comparison must show that the dry chemical meets CCV limits. The comparison studies are maintained in the QA office.

Wherever possible, standards must be traceable to national or international standards of measurement or to national or international reference materials. Records to that effect are available to the user.

Compressed gases in use are checked for pressure and secure positioning daily. The minimum total pressure must be 500 psig or the tank must be replaced. The quality of the gases must meet method or manufacturer specification or be of a grade that does not cause any analytical interference.

Water used in the preparation of standards or reagents must have a resistivity of greater than 10 megaohm-cm at 25°C. The conductivity is checked and recorded daily. If the water's conductivity is outside the specified limit, the Wet Chemistry Department Manager must be notified immediately in order to notify all departments, decide on cessation (based on intended use) of activities, and make arrangements for correction.

The laboratory may purchase reagent grade (or other similar quality) for use in the laboratory. This water must be certified "clean" by the supplier for all target analytes or otherwise verified by the laboratory prior to use. This verification is documented.

Standard lots are verified before first time use if the laboratory switches manufacturers or has historically had a problem with the type of standard.

Purchased VOA vials must be certified clean and the certificates must be maintained. If uncertified VOA vials are purchased, all lots must be verified clean prior to use. This verification must be maintained.

9.3.4 Storage

Reagent and chemical storage is important from the aspects of both integrity and safety. Light-sensitive reagents may be stored in brown-glass containers. Table 9-1 details specific storage instructions for reagents and chemicals. Section 22 discusses conditions for standard storage.

9.4 PURCHASE OF EQUIPMENT/INSTRUMENTS/SOFTWARE

When a new piece of equipment is needed, either for additional capacity or for replacing inoperable equipment, the analyst or Department Manager makes a supply request to the Laboratory Director. If they agree with the request the procedures outlined in Policy No. CA-T-P-001, Qualified Products List are followed. A decision is made as to which piece of equipment can best satisfy the requirements. The appropriate written requests are completed and purchasing places the order.

Upon receipt of a new or used piece of equipment, it is given an instrument identifier and the equipment is added to the laboratory equipment list described in Section 21 that is maintained

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Appendix B
Laboratory Reporting Limits

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

TO15 in Air (EPA TO15)
Prep Method: N Canister prep
Container: Air Canister
Preservation: None
Amount Required:
Hold Time: 30 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
1,4-Dichlorobenzene	0.20	0.50 ppbv					65 - 135	25
1,1,1-Trichloroethane	0.16	0.50 ppbv					65 - 135	25
Bromomethane	0.14	0.50 ppbv					65 - 135	25
Bromoform	0.19	0.50 ppbv					65 - 135	25
Bromoethene(Vinyl Bromide)	0.15	0.50 ppbv					65 - 135	25
Bromodichloromethane	0.17	0.50 ppbv					65 - 135	25
Benzyl Chloride	0.31	2.0 ppbv					65 - 135	25
Benzene	0.12	0.50 ppbv					65 - 135	25
Allyl Chloride	0.12	0.50 ppbv					65 - 135	25
Acetone	1.4	5.0 ppbv					65 - 135	25
4-Methyl-2-pentanone (MIBK)	0.13	1.0 ppbv					65 - 135	25
4-Ethyltoluene	0.12	0.50 ppbv					65 - 135	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	Blank Spike / LCS %R	Blank Spike / LCS RPD
2-Propanol	0.11	2.0 ppbv					65 - 135	25
2-Hexanone	0.12	1.0 ppbv					65 - 135	25
Carbon tetrachloride	0.16	0.50 ppbv					65 - 135	25
1,2-Dichlorobenzene	0.17	0.50 ppbv					65 - 135	25
1,1,2,2-Tetrachloroethane	0.16	0.50 ppbv					65 - 135	25
1,1,2-Trichloroethane	0.15	0.50 ppbv					65 - 135	25
1,1-Dichloroethane	0.13	0.50 ppbv					65 - 135	25
1,1-Dichloroethene	0.17	0.50 ppbv					65 - 135	25
1,2,4-Trichlorobenzene	0.49	2.0 ppbv					65 - 135	25
2-Butanone (MEK)	0.21	1.0 ppbv					65 - 135	25
1,2-Dibromoethane (EDB)	0.13	0.50 ppbv					65 - 135	25
2,2,4-Trimethylpentane	0.12	0.50 ppbv					65 - 135	25
1,2-Dichloroethane	0.14	0.50 ppbv					65 - 135	25
1,2-Dichloropropane	0.17	0.50 ppbv					65 - 135	25
1,3,5-Trimethylbenzene	0.12	0.50 ppbv					65 - 135	25
1,3-Butadiene	0.14	0.50 ppbv					65 - 135	25
1,3-Dichlorobenzene	0.18	0.50 ppbv					65 - 135	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Chlorobenzene	0.14	0.50 ppbv					65 - 135	25
1,2,4-Trimethylbenzene	0.14	0.50 ppbv					65 - 135	25
Tetrahydrofuran	1.7	2.0 ppbv					65 - 135	25
Carbon disulfide	0.13	0.50 ppbv					65 - 135	25
Methyl-tert-butyl Ether (MTBE)	0.12	1.0 ppbv					65 - 135	25
Methylene Chloride	0.14	0.50 ppbv					65 - 135	25
o-Xylene	0.14	0.50 ppbv					65 - 135	25
Propene	0.16	0.50 ppbv					65 - 135	25
Hexane	0.12	0.50 ppbv					65 - 135	25
Tetrachloroethene	0.18	0.50 ppbv					65 - 135	25
Hexachlorobutadiene	0.20	1.0 ppbv					65 - 135	25
Toluene	0.14	0.50 ppbv					65 - 135	25
trans-1,2-Dichloroethene	0.13	0.50 ppbv					65 - 135	25
trans-1,3-Dichloropropene	0.12	0.50 ppbv					65 - 135	25
Trichloroethene	0.15	0.50 ppbv					65 - 135	25
Trichlorofluoromethane	0.17	0.50 ppbv					65 - 135	25
Vinyl Acetate	0.11	0.50 ppbv					65 - 135	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	Blank Spike / LCS %R	Blank Spike / LCS RPD
Styrene	0.13	0.50 ppbv					65 - 135	25
Dichlorodifluoromethane	0.17	0.50 ppbv					65 - 135	25
Chloroethane	0.17	0.50 ppbv					65 - 135	25
Chloroform	0.14	0.50 ppbv					65 - 135	25
Chloromethane	0.19	0.50 ppbv					65 - 135	25
cis-1,2-Dichloroethene	0.13	0.50 ppbv					65 - 135	25
cis-1,3-Dichloropropene	0.14	0.50 ppbv					65 - 135	25
m,p-Xylenes	0.26	1.0 ppbv					65 - 135	25
Dibromochloromethane	0.15	0.50 ppbv					65 - 135	25
Vinyl chloride	0.15	0.50 ppbv					65 - 135	25
Dichlorotetrafluoroethane(F-114)	0.16	0.50 ppbv					65 - 135	25
Ethyl Acetate	0.096	0.50 ppbv					65 - 135	25
Ethylbenzene	0.13	0.50 ppbv					65 - 135	25
Freon 113	0.16	0.50 ppbv					65 - 135	25
Heptane	0.15	0.50 ppbv					65 - 135	25
Cyclohexane	0.15	0.50 ppbv					65 - 135	25
surr: 4-Bromofluorobenzene	0.0		70 - 130				70 - 130	0

** = Analyte not a part of normal reporting list. Special request only*

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

8260 Ultra Low Long List in Water (EPA 8260B)
Prep Method: EPA 5030 GCMS
Container: 40 ml Voa Vial
Preservation: 4 C, HCL
Amount Required: 80 ml
Hold Time: 14 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Acetone	3.2	10 ug/l			10 - 150	35	10 - 150	35
Benzene	0.37	0.50 ug/l			70 - 125	25	80 - 120	15
Bromobenzene	0.28	0.50 ug/l			75 - 120	20	80 - 120	15
Bromochloromethane	0.18	0.50 ug/l			75 - 130	20	80 - 125	15
Bromodichloromethane	0.090	0.50 ug/l			75 - 125	20	80 - 120	15
Bromoform	0.44	1.0 ug/l			65 - 125	25	75 - 130	20
Bromomethane	0.19	1.0 ug/l			45 - 150	35	55 - 150	20
2-Butanone (MEK)	1.3	2.5 ug/l			15 - 150	30	40 - 150	35
n-Butylbenzene	0.29	0.50 ug/l			70 - 130	30	80 - 130	15
sec-Butylbenzene	0.24	0.50 ug/l			70 - 125	30	80 - 125	15
tert-Butylbenzene	0.30	0.50 ug/l			70 - 125	25	80 - 120	15
Carbon disulfide	0.16	0.50 ug/l			65 - 145	25	70 - 140	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Carbon tetrachloride	0.080	0.50 ug/l			65 - 135	25	75 - 130	20
Chlorobenzene	0.12	0.50 ug/l			75 - 120	20	80 - 120	15
Chloroethane	0.10	1.0 ug/l			65 - 140	25	70 - 130	15
Chloroform	0.090	0.50 ug/l			70 - 130	20	75 - 120	15
Chloromethane	0.17	1.0 ug/l			55 - 145	35	60 - 140	20
2-Chlorotoluene	0.26	0.50 ug/l			70 - 125	25	80 - 120	15
4-Chlorotoluene	0.32	0.50 ug/l			70 - 125	25	80 - 120	15
Dibromochloromethane	0.090	0.50 ug/l			70 - 130	20	80 - 120	15
1,2-Dibromo-3-chloropropane	0.87	2.5 ug/l			50 - 150	30	50 - 150	35
1,2-Dibromoethane (EDB)	0.14	0.50 ug/l			70 - 125	20	80 - 120	15
Dibromomethane	0.33	0.50 ug/l			70 - 120	20	75 - 120	15
1,2-Dichlorobenzene	0.47	0.50 ug/l			75 - 120	20	80 - 120	15
1,3-Dichlorobenzene	0.33	0.50 ug/l			75 - 120	25	80 - 120	15
1,4-Dichlorobenzene	0.35	0.50 ug/l			70 - 125	20	80 - 120	15
Dichlorodifluoromethane	0.070	0.50 ug/l			60 - 150	30	60 - 150	30
1,1-Dichloroethane	0.060	0.50 ug/l			70 - 130	20	70 - 125	15
1,2-Dichloroethane	0.090	0.50 ug/l			65 - 140	20	75 - 130	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
1,1-Dichloroethene	0.21	0.50 ug/l			70 - 130	25	75 - 125	20
cis-1,2-Dichloroethene	0.11	0.50 ug/l			70 - 125	20	80 - 120	15
trans-1,2-Dichloroethene	0.090	0.50 ug/l			75 - 125	25	80 - 120	15
1,2-Dichloropropane	0.15	0.50 ug/l			75 - 125	20	80 - 120	15
1,3-Dichloropropane	0.11	0.50 ug/l			70 - 120	20	80 - 120	15
2,2-Dichloropropane	0.050	1.0 ug/l			65 - 140	25	75 - 130	15
1,1-Dichloropropene	0.29	0.50 ug/l			65 - 130	25	75 - 120	15
cis-1,3-Dichloropropene	0.10	0.50 ug/l			75 - 130	20	80 - 120	15
trans-1,3-Dichloropropene	0.19	0.50 ug/l			70 - 130	20	80 - 125	15
Ethylbenzene	0.10	0.50 ug/l			70 - 125	25	80 - 120	15
Hexachlorobutadiene	0.28	1.0 ug/l			40 - 150	30	40 - 150	35
2-Hexanone	0.93	2.5 ug/l			20 - 150	30	20 - 150	35
Iodomethane	0.10	2.5 ug/l			60 - 150	30	80 - 130	10
Isopropylbenzene	0.19	0.50 ug/l			75 - 130	25	80 - 130	15
p-Isopropyltoluene	0.27	0.50 ug/l			70 - 130	30	80 - 130	15
Methylene Chloride	0.11	1.0 ug/l			65 - 130	20	70 - 120	15
4-Methyl-2-pentanone (MIBK)	0.45	2.5 ug/l			55 - 135	25	60 - 135	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Methyl-tert-butyl Ether (MTBE)	0.12	0.50 ug/l			65 - 140	25	70 - 130	20
Naphthalene	0.45	2.5 ug/l			40 - 150	30	40 - 150	30
n-Propylbenzene	0.21	0.50 ug/l			70 - 130	30	75 - 130	15
Styrene	0.21	0.50 ug/l			55 - 135	35	80 - 120	15
1,1,1,2-Tetrachloroethane	0.29	0.50 ug/l			70 - 125	20	75 - 125	15
1,1,2,2-Tetrachloroethane	0.090	0.50 ug/l			70 - 125	25	80 - 120	20
Tetrachloroethene	0.19	0.50 ug/l			65 - 130	25	70 - 130	20
Toluene	0.080	0.50 ug/l			70 - 125	20	80 - 120	15
1,2,3-Trichlorobenzene	0.40	1.0 ug/l			50 - 150	35	55 - 150	35
1,2,4-Trichlorobenzene	0.43	1.0 ug/l			50 - 150	25	50 - 150	30
1,1,1-Trichloroethane	0.080	0.50 ug/l			70 - 130	25	75 - 125	15
1,1,2-Trichloroethane	0.15	0.50 ug/l			75 - 125	20	80 - 120	15
Trichloroethene	0.050	0.50 ug/l			70 - 125	25	80 - 120	15
Trichlorofluoromethane	0.090	0.50 ug/l			65 - 150	25	70 - 150	25
1,2,3-Trichloropropane	0.54	1.0 ug/l			70 - 130	25	70 - 130	20
1,2,4-Trimethylbenzene	0.26	0.50 ug/l			70 - 125	30	80 - 120	15
1,3,5-Trimethylbenzene	0.20	0.50 ug/l			75 - 130	25	80 - 130	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Vinyl Acetate	0.18	0.50 ug/l			40 - 150	30	40 - 150	25
Vinyl chloride	0.11	0.50 ug/l			60 - 140	25	70 - 130	20
Xylenes, Total	0.42	1.0 ug/l			75 - 120	15	60 - 140	15
surr: Dibromofluoromethane			80 - 130					
surr: Toluene-d8			80 - 120					
surr: 4-Bromofluorobenzene			80 - 125					
*o-Xylene	0.15	0.50 ug/l						
*m,p-Xylenes	0.27	1.0 ug/l						
*Freon 113	0.10	2.0 ug/l				20		15
*n-Hexane	0.27	1.0 ug/l			70 - 130	20	70 - 130	20

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_1,4-Dioxane (SW8270C) in Water (SW8270C)
Prep Method: N_EPA 3520C
Container: 1 L Amber
Preservation: 4 C, Cool
Amount Required:
Hold Time: 7 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
1,4-Dioxane	0.10	1.0 ug/l		25	70 - 130	25	80 - 120	25
surr: Nitrobenzene-d5	0.0		59.9 - 120	0	59 - 120	0	38 - 125	0
surr: 1,4-Dioxane-d8	0.0		38.6 - 88.3	0	36 - 81	0	32 - 57	0

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

8260 in Soil (SW8260B)
Prep Method: EPA 5035 GCMS
Container: Encore
Preservation: 4 C, Cool
Amount Required:
Hold Time: 2 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
1,1,1-Trichloroethane	19	50 ug/kg			50 - 125	15	75 - 120	15
1,1,2,2-Tetrachloroethane	18	50 ug/kg			50 - 130	25	60 - 125	30
1,1,2-Trichloroethane	23	50 ug/kg			55 - 120	25	65 - 125	30
1,1-Dichloroethane	15	50 ug/kg			55 - 125	25	70 - 125	20
1,1-Dichloroethene	23	50 ug/kg			25 - 140	35	50 - 135	20
1,1-Dichloropropene	19	50 ug/kg			55 - 125	25	75 - 120	15
1,2,3-Trichlorobenzene	18	100 ug/kg			35 - 140	30	55 - 140	25
1,2,3-Trichloropropane	20	100 ug/kg			35 - 140	35	60 - 130	30
1,2,4-Trimethylbenzene	27	50 ug/kg			50 - 130	20	75 - 120	15
1,2-Dibromoethane (EDB)	16	50 ug/kg			55 - 120	25	70 - 120	20
1,2-Dichlorobenzene	21	50 ug/kg			60 - 120	25	80 - 120	20
1,2-Dichloroethane	29	50 ug/kg			55 - 130	25	70 - 130	20

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
1,2-Dichloropropane	19	50 ug/kg			60 - 120	25	80 - 120	20
1,3,5-Trimethylbenzene	16	50 ug/kg			45 - 135	20	80 - 130	15
1,3-Dichlorobenzene	12	50 ug/kg			60 - 120	25	80 - 120	15
1,3-Dichloropropane	14	50 ug/kg			60 - 120	25	70 - 120	20
1,4-Dichlorobenzene	19	50 ug/kg			60 - 120	20	80 - 120	15
2,2-Dichloropropane	25	100 ug/kg			45 - 130	25	65 - 130	20
2-Butanone (MEK)	200	500 ug/kg			40 - 150	35	40 - 150	35
2-Chlorotoluene	15	50 ug/kg			60 - 120	20	80 - 120	15
2-Hexanone	210	250 ug/kg			20 - 150	35	20 - 150	35
4-Chlorotoluene	18	50 ug/kg			55 - 130	20	80 - 120	15
4-Methyl-2-pentanone (MIBK)	170	250 ug/kg			40 - 130	30	50 - 130	35
Acetone	330	500 ug/kg			10 - 150	35	10 - 150	35
Benzene	23	50 ug/kg			55 - 120	25	75 - 120	15
Bromobenzene	18	50 ug/kg			60 - 125	25	80 - 120	20
Bromochloromethane	24	50 ug/kg			50 - 135	30	75 - 125	20
Bromodichloromethane	18	50 ug/kg			60 - 120	20	75 - 120	15
Bromoform	20	50 ug/kg			40 - 125	35	60 - 120	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Bromomethane	8.3	250 ug/kg			10 - 140	35	20 - 140	35
Carbon tetrachloride	20	50 ug/kg			40 - 135	30	70 - 130	20
Chlorobenzene	11	50 ug/kg			65 - 120	20	80 - 120	15
Chloroethane	31	50 ug/kg			10 - 140	35	10 - 130	30
Chloroform	24	50 ug/kg			60 - 125	25	75 - 120	20
Chloromethane	26	250 ug/kg			10 - 140	35	25 - 140	35
cis-1,2-Dichloroethene	21	50 ug/kg			55 - 125	25	70 - 125	15
cis-1,3-Dichloropropene	15	50 ug/kg			55 - 120	20	75 - 125	15
Dibromochloromethane	11	50 ug/kg			55 - 125	30	75 - 120	20
Dichlorodifluoromethane	19	50 ug/kg			10 - 150	35	10 - 150	35
Ethylbenzene	13	50 ug/kg			60 - 125	20	80 - 120	15
m,p-Xylenes	34	100 ug/kg			55 - 125	20	60 - 140	15
Methyl-tert-butyl Ether (MTBE)	17	50 ug/kg			50 - 130	35	65 - 130	20
Methylene Chloride	32	100 ug/kg			50 - 120	30	65 - 125	20
n-Butylbenzene	18	50 ug/kg			40 - 135	25	65 - 130	20
n-Propylbenzene	17	50 ug/kg			55 - 130	20	75 - 130	15
o-Xylene	16	50 ug/kg			60 - 125	30	80 - 120	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
p-Isopropyltoluene	20	50 ug/kg			45 - 135	25	75 - 130	15
sec-Butylbenzene	18	50 ug/kg			50 - 130	20	75 - 125	15
Styrene	12	50 ug/kg			55 - 125	20	80 - 120	15
tert-Butylbenzene	20	50 ug/kg			55 - 125	25	80 - 120	15
Tetrachloroethene	9.4	50 ug/kg			60 - 130	20	70 - 130	15
Toluene	15	50 ug/kg			55 - 125	35	75 - 120	15
trans-1,2-Dichloroethene	18	50 ug/kg			50 - 130	25	70 - 130	20
trans-1,3-Dichloropropene	15	50 ug/kg			55 - 125	25	65 - 130	20
Trichloroethene	21	50 ug/kg			40 - 145	35	80 - 120	15
Trichlorofluoromethane	32	50 ug/kg			20 - 150	35	50 - 150	25
Vinyl Acetate	26	50 ug/kg			10 - 150	35	35 - 150	35
Vinyl chloride	25	50 ug/kg			10 - 150	35	10 - 150	35
*1,1,1,2-Tetrachloroethane	20	50 ug/kg			40 - 140	25	75 - 125	15
*1,2,4-Trichlorobenzene	20	100 ug/kg			45 - 150	25	50 - 150	25
*1,2-Dibromo-3-chloropropane	39	100 ug/kg			35 - 150	35	50 - 150	35
*Carbon disulfide	21	50 ug/kg			20 - 130	35	40 - 135	25
*Dibromomethane	13	50 ug/kg			40 - 150	25	70 - 120	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
*Hexachlorobutadiene	20	100 ug/kg			40 - 150	30	40 - 150	25
*Hexachloroethane	24	100 ug/kg				25		25
*Iodomethane	62	250 ug/kg			30 - 140	30	55 - 140	20
*Isopropylbenzene	15	50 ug/kg			50 - 150	25	80 - 130	20
*Naphthalene	28	250 ug/kg			35 - 150	35	40 - 150	30
*Tetrahydrofuran	140	250 ug/kg				25		25
*trans-1,4-Dichloro-2-butene	24	100 ug/kg				25		25
*Total Trihalomethanes	0.20	50 ug/kg						
*Xylenes, Total	44	100 ug/kg			50 - 125	20	80 - 120	15
surr: Dibromofluoromethane	0.0		60 - 130					
surr: Toluene-d8	0.0		65 - 125					
surr: 4-Bromofluorobenzene	0.0		65 - 125					

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_8015AZR1 in Soil (8015AZ R.1)
Prep Method: N 8015-AZ R1
Container: 4 oz Jar
Preservation: 4 C, Cool
Amount Required: 30 g
Hold Time: 14 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
*Gas Hydrocarbons:C6-C10 (Mod.)	20	20 mg/kg						
DRO (C10-C22)	30	30 mg/kg			70 - 160	25	70 - 130	20
ORO (C22-C32)	100	100 mg/kg			70 - 175	20	70 - 130	20
Total (C10-C32)	130	130 mg/kg						
surr: o-terphenyl			70 - 130					

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

8260 Ultra Low Long List in Water (EPA 8260B)
Prep Method: EPA 5030 GCMS
Container: 40 ml Voa Vial
Preservation: 4 C, HCL
Amount Required: 80 ml
Hold Time: 14 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Acetone	3.2	10 ug/l			10 - 150	35	10 - 150	35
Benzene	0.37	0.50 ug/l			70 - 125	25	80 - 120	15
Bromobenzene	0.28	0.50 ug/l			75 - 120	20	80 - 120	15
Bromochloromethane	0.18	0.50 ug/l			75 - 130	20	80 - 125	15
Bromodichloromethane	0.090	0.50 ug/l			75 - 125	20	80 - 120	15
Bromoform	0.44	1.0 ug/l			65 - 125	25	75 - 130	20
Bromomethane	0.19	1.0 ug/l			45 - 150	35	55 - 150	20
2-Butanone (MEK)	1.3	2.5 ug/l			15 - 150	30	40 - 150	35
n-Butylbenzene	0.29	0.50 ug/l			70 - 130	30	80 - 130	15
sec-Butylbenzene	0.24	0.50 ug/l			70 - 125	30	80 - 125	15
tert-Butylbenzene	0.30	0.50 ug/l			70 - 125	25	80 - 120	15
Carbon disulfide	0.16	0.50 ug/l			65 - 145	25	70 - 140	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Carbon tetrachloride	0.080	0.50 ug/l			65 - 135	25	75 - 130	20
Chlorobenzene	0.12	0.50 ug/l			75 - 120	20	80 - 120	15
Chloroethane	0.10	1.0 ug/l			65 - 140	25	70 - 130	15
Chloroform	0.090	0.50 ug/l			70 - 130	20	75 - 120	15
Chloromethane	0.17	1.0 ug/l			55 - 145	35	60 - 140	20
2-Chlorotoluene	0.26	0.50 ug/l			70 - 125	25	80 - 120	15
4-Chlorotoluene	0.32	0.50 ug/l			70 - 125	25	80 - 120	15
Dibromochloromethane	0.090	0.50 ug/l			70 - 130	20	80 - 120	15
1,2-Dibromo-3-chloropropane	0.87	2.5 ug/l			50 - 150	30	50 - 150	35
1,2-Dibromoethane (EDB)	0.14	0.50 ug/l			70 - 125	20	80 - 120	15
Dibromomethane	0.33	0.50 ug/l			70 - 120	20	75 - 120	15
1,2-Dichlorobenzene	0.47	0.50 ug/l			75 - 120	20	80 - 120	15
1,3-Dichlorobenzene	0.33	0.50 ug/l			75 - 120	25	80 - 120	15
1,4-Dichlorobenzene	0.35	0.50 ug/l			70 - 125	20	80 - 120	15
Dichlorodifluoromethane	0.070	0.50 ug/l			60 - 150	30	60 - 150	30
1,1-Dichloroethane	0.060	0.50 ug/l			70 - 130	20	70 - 125	15
1,2-Dichloroethane	0.090	0.50 ug/l			65 - 140	20	75 - 130	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
1,1-Dichloroethene	0.21	0.50 ug/l			70 - 130	25	75 - 125	20
cis-1,2-Dichloroethene	0.11	0.50 ug/l			70 - 125	20	80 - 120	15
trans-1,2-Dichloroethene	0.090	0.50 ug/l			75 - 125	25	80 - 120	15
1,2-Dichloropropane	0.15	0.50 ug/l			75 - 125	20	80 - 120	15
1,3-Dichloropropane	0.11	0.50 ug/l			70 - 120	20	80 - 120	15
2,2-Dichloropropane	0.050	1.0 ug/l			65 - 140	25	75 - 130	15
1,1-Dichloropropene	0.29	0.50 ug/l			65 - 130	25	75 - 120	15
cis-1,3-Dichloropropene	0.10	0.50 ug/l			75 - 130	20	80 - 120	15
trans-1,3-Dichloropropene	0.19	0.50 ug/l			70 - 130	20	80 - 125	15
Ethylbenzene	0.10	0.50 ug/l			70 - 125	25	80 - 120	15
Hexachlorobutadiene	0.28	1.0 ug/l			40 - 150	30	40 - 150	35
2-Hexanone	0.93	2.5 ug/l			20 - 150	30	20 - 150	35
Iodomethane	0.10	2.5 ug/l			60 - 150	30	80 - 130	10
Isopropylbenzene	0.19	0.50 ug/l			75 - 130	25	80 - 130	15
p-Isopropyltoluene	0.27	0.50 ug/l			70 - 130	30	80 - 130	15
Methylene Chloride	0.11	1.0 ug/l			65 - 130	20	70 - 120	15
4-Methyl-2-pentanone (MIBK)	0.45	2.5 ug/l			55 - 135	25	60 - 135	25

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Methyl-tert-butyl Ether (MTBE)	0.12	0.50 ug/l			65 - 140	25	70 - 130	20
Naphthalene	0.45	2.5 ug/l			40 - 150	30	40 - 150	30
n-Propylbenzene	0.21	0.50 ug/l			70 - 130	30	75 - 130	15
Styrene	0.21	0.50 ug/l			55 - 135	35	80 - 120	15
1,1,1,2-Tetrachloroethane	0.29	0.50 ug/l			70 - 125	20	75 - 125	15
1,1,2,2-Tetrachloroethane	0.090	0.50 ug/l			70 - 125	25	80 - 120	20
Tetrachloroethene	0.19	0.50 ug/l			65 - 130	25	70 - 130	20
Toluene	0.080	0.50 ug/l			70 - 125	20	80 - 120	15
1,2,3-Trichlorobenzene	0.40	1.0 ug/l			50 - 150	35	55 - 150	35
1,2,4-Trichlorobenzene	0.43	1.0 ug/l			50 - 150	25	50 - 150	30
1,1,1-Trichloroethane	0.080	0.50 ug/l			70 - 130	25	75 - 125	15
1,1,2-Trichloroethane	0.15	0.50 ug/l			75 - 125	20	80 - 120	15
Trichloroethene	0.050	0.50 ug/l			70 - 125	25	80 - 120	15
Trichlorofluoromethane	0.090	0.50 ug/l			65 - 150	25	70 - 150	25
1,2,3-Trichloropropane	0.54	1.0 ug/l			70 - 130	25	70 - 130	20
1,2,4-Trimethylbenzene	0.26	0.50 ug/l			70 - 125	30	80 - 120	15
1,3,5-Trimethylbenzene	0.20	0.50 ug/l			75 - 130	25	80 - 130	15

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Vinyl Acetate	0.18	0.50 ug/l			40 - 150	30	40 - 150	25
Vinyl chloride	0.11	0.50 ug/l			60 - 140	25	70 - 130	20
Xylenes, Total	0.42	1.0 ug/l			75 - 120	15	60 - 140	15
surr: Dibromofluoromethane			80 - 130					
surr: Toluene-d8			80 - 120					
surr: 4-Bromofluorobenzene			80 - 125					
*o-Xylene	0.15	0.50 ug/l						
*m,p-Xylenes	0.27	1.0 ug/l						
*Freon 113	0.10	2.0 ug/l				20		15
*n-Hexane	0.27	1.0 ug/l			70 - 130	20	70 - 130	20

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

8015D (Gas) in Water (EPA 8015D)
Prep Method: EPA 5030 BTEX
Container: 40 ml VOA w/HCL
Preservation: 4 C, HCL
Amount Required: 80 ml
Hold Time: 14 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Volatile Fuel Hydrocarbons	0.023	0.20 mg/l			35 - 145	20	80 - 130	20
surr: 4-BFB (FID)			60 - 145					

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_8015D (Diesel) in Water (EPA 8015D)
Prep Method: EPA 3510C
Container: 1 L Amber
Preservation: 4 C, Cool
Amount Required: 4 L (1 L min.)
Hold Time: 7 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
DRO (C10-C22)	0.098	0.10 mg/l			70 - 130	20	54 - 114	20
ORO (C22-C32)	0.13	0.20 mg/l			70 - 130	20	75 - 141	20
Total (C10-C32)	0.23	0.30 mg/l						
surr: o-terphenyl			37 - 142		70 - 130		68 - 120	

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_8310 (PAHs) in Water (SW8310)
Prep Method: N_EPA 3520C
Container: 1 L Amber
Preservation: 4 C, Cool
Amount Required:
Hold Time: 7 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Chrysene	0.013	0.10 ug/l			40 - 135	35	61 - 128	35
Acenaphthene	0.058	1.0 ug/l			44 - 116	35	52 - 122	35
Acenaphthylene	0.69	1.0 ug/l			52 - 113	35	55 - 122	35
Anthracene	0.041	0.050 ug/l			50 - 118	35	68 - 134	35
Benzanthracene	0.030	0.20 ug/l			41 - 129	35	56 - 103	35
Benzo(a)pyrene	0.012	0.050 ug/l			44 - 124	35	57 - 116	35
Benzo(b)fluoranthene	0.021	0.10 ug/l			39 - 135	35	62 - 119	35
Benzo(k)fluoranthene	0.011	0.050 ug/l			40 - 135	35	56 - 117	35
Pyrene	0.038	0.10 ug/l			43 - 129	35	67 - 125	35
Dibenz(a,h)anthracene	0.035	0.10 ug/l			38 - 143	35	44 - 125	35
Fluoranthene	0.031	0.10 ug/l			43 - 129	35	67 - 117	35
Fluorene	0.084	0.10 ug/l			49 - 115	35	56 - 132	35
Indeno(1,2,3-cd)pyrene	0.011	0.10 ug/l			38 - 133	35	52 - 125	35

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Naphthalene	0.43	0.50 ug/l			46 - 109	35	41 - 116	35
Phenanthrene	0.036	0.10 ug/l			50 - 126	35	64 - 140	35
Benzo(g,h,i)perylene	0.019	0.10 ug/l			43 - 131	35	54 - 121	35
surr: 2-Chloroanthracene	0.0		48.2 - 124		48.2 - 124	0	62 - 126	0

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_ICP Arsenic, Barium, Cadmium, Chromium, Lead, Selenium, Silver (6010B) in
Prep Method: N 3005A W
Container: 500 ml Poly
Preservation: 4 C, HNO3
Amount Required:
Hold Time: 180 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Arsenic	0.014	0.10 mg/l			70 - 130	20	85 - 115	20
Barium	0.00040	0.10 mg/l			70 - 130	20	85 - 115	20
Cadmium	0.00080	0.0010 mg/l			70 - 130	20	85 - 115	20
Chromium	0.0012	0.010 mg/l			70 - 130	20	85 - 115	20
Lead	0.0060	0.015 mg/l			70 - 130	20	85 - 115	20
Selenium	0.037	0.10 mg/l			70 - 130	20	85 - 115	20
Silver	0.0038	0.010 mg/l			70 - 130	20	85 - 115	20

** = Analyte not a part of normal reporting list. Special request only*

N_Mercury (7470) in Water (SW7470A)
Prep Method: N EPA 245.1/7470A Hg
Container: 500 ml Poly
Preservation: 4 C HNO3
Amount Required:
Hold Time: 28 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Mercury	0.000089	0.00050 mg/l		20	85 - 115	20	85 - 115	20

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

Chromium VI in Water (SM3500CR-D)
Prep Method: None
Container: 500 ml Poly
Preservation: 4 C, Cool
Amount Required: 100 ml
Hold Time: 1 day

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Chromium VI	0.0012	0.010 mg/l			80 - 120	20	85 - 115	20

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

Cyanide (9014) in Water (SW9010C/9014)
Prep Method: N SW-846 9010C
Container: 1 L Poly w/NaOH
Preservation: 4 C, NaOH
Amount Required:
Hold Time: 28 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Cyanide	0.0047	0.010 mg/l		20	80 - 120	20	90 - 110	20

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

N_8082 (PCBs) in Water (SW8082)
Prep Method: N_EPA 3510C
Container: 1 L Amber
Preservation: 4 C, Cool
Amount Required: 4X I L
Hold Time: 7 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Aroclor 1016	0.45	1.0 ug/l			10 - 147	35	50 - 110	20
Aroclor 1221	0.20	1.0 ug/l				0		0
Aroclor 1232	0.48	1.0 ug/l				0		0
Aroclor 1242	0.55	1.0 ug/l				0		0
Aroclor 1248	0.39	1.0 ug/l				0		0
Aroclor 1254	0.16	1.0 ug/l				0		0
Aroclor 1260	0.29	1.0 ug/l			10 - 153	35	55 - 115	20
surr: Tetrachloro-m-xylene	0.0		40 - 120		10 - 140	0	40 - 120	0
surr: Decachlorobiphenyl	0.0		10 - 125		10 - 133	0	10 - 125	0

** = Analyte not a part of normal reporting list. Special request only*

TestAmerica Method Detection Limits, Reporting Limits, and Control Limits

3/12/2010

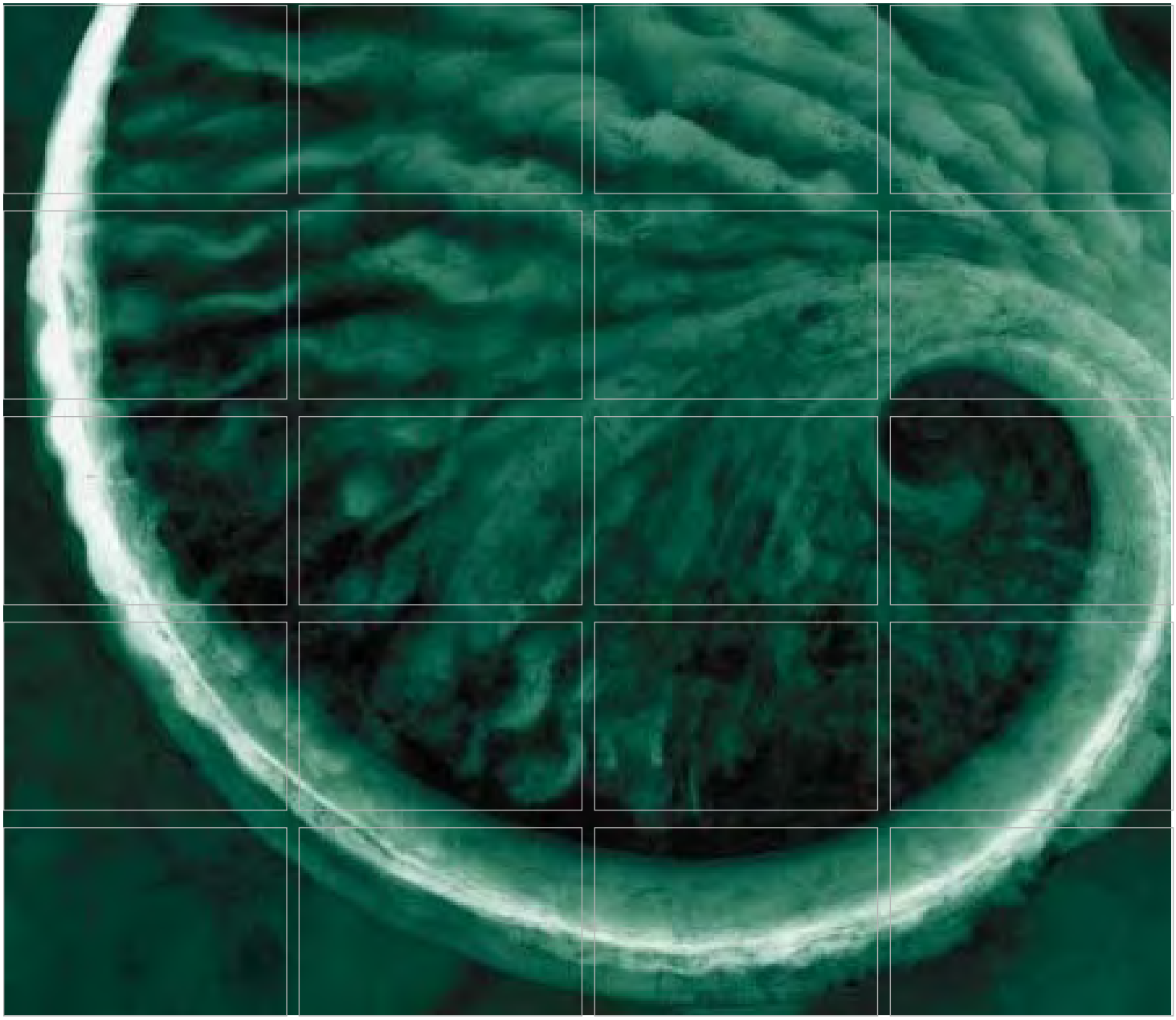
N_8081A (Pesticides) in Water (SW8081A)
Prep Method: N_EPA 3510C
Container: 1 L Amber
Preservation: 4 C, Cool (Dark)
Amount Required:
Hold Time: 7 days

		Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
Analyte	**MDL**				**%R**	**RPD**	**%R**	**RPD**
Endosulfan II	0.019	0.050 ug/l			74 - 112	35	50 - 120	35
4,4'-DDE	0.038	0.050 ug/l			64 - 108	35	50 - 115	35
4,4'-DDT	0.041	0.050 ug/l			55 - 118	35	40 - 125	35
Aldrin	0.034	0.050 ug/l			51 - 110	35	40 - 105	35
alpha-BHC	0.013	0.050 ug/l			74 - 102	35	50 - 120	35
beta-BHC	0.016	0.050 ug/l			76 - 106	35	55 - 125	35
Chlordane	0.092	0.50 ug/l			70 - 130	35	70 - 130	35
delta-BHC	0.010	0.050 ug/l			75 - 116	35	50 - 125	35
4,4'-DDD	0.0095	0.050 ug/l			73 - 107	35	65 - 110	35
Endosulfan I	0.023	0.050 ug/l			79 - 103	35	55 - 115	35
Toxaphene	0.26	1.0 ug/l			70 - 130	35	70 - 130	35
Endosulfan sulfate	0.016	0.050 ug/l			70 - 124	35	50 - 125	35

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike		Blank Spike / LCS	
					%R	RPD	%R	RPD
Endrin	0.018	0.050 ug/l			70 - 110	35	50 - 120	35
Endrin aldehyde	0.034	0.050 ug/l			75 - 116	35	50 - 125	35
gamma-BHC (Lindane)	0.011	0.050 ug/l			77 - 102	35	50 - 120	35
Heptachlor	0.029	0.050 ug/l			64 - 104	35	40 - 110	35
Heptachlor epoxide	0.017	0.050 ug/l			68 - 107	35	55 - 120	35
Methoxychlor	0.042	0.10 ug/l			66 - 112	35	45 - 120	35
Dieldrin	0.038	0.050 ug/l			71 - 112	35	55 - 115	35
surr: Decachlorobiphenyl	0.0		25 - 130		25 - 130	0	40 - 115	0
surr: Tetrachloro-m-xylene	0.0		10 - 100		10 - 100	0	15 - 95	0

** = Analyte not a part of normal reporting list. Special request only*

Appendix C
Health and Safety Plan



Site-Specific Health and Safety Plan

52nd Street Superfund Site Operable Unit 3 Study Area
Phoenix, Arizona

August 2010

Prepared for:
Motorola 52nd Street
Superfund Site
Operable Unit 3
Working Group

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Working Group

Site-Specific Health and Safety Plan

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August 2010

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LIST OF ACRONYMS

^{o}F	Degrees Fahrenheit
ADEQ	Arizona Department of Environmental Quality
COP	City of Phoenix
ERM	ERM-West, Inc.
HASP	Health and Safety Plan
HSO	Health and Safety Officer
IDW	Investigation-Derived Waste
OU	Operable Unit
PIC	Principal-in-Charge
PM	Project Manager
PPE	Personal protective equipment
SSO	Site safety officer
THA	Task Hazard Analysis

1.0 SITE-SPECIFIC HEALTH AND SAFETY PLAN

ERM-West, Inc. (ERM) developed the following Health and Safety Plan (HASP) for use by ERM personnel and by ERM contractors (individually, an "ERM Contractor" and collectively, "ERM Contractors"). ERM personnel must adhere to the practices and procedures specified in the HASP. Each ERM Contractor must review the HASP and agree to accept and abide by the HASP, subject to any modifications to the HASP (to address the ERM Contractor's more stringent practices and procedures) agreed upon in writing by ERM and the ERM Contractor. The ERM Contractor shall indicate such acceptance by signing Section 20 of this document prior to commencing work at the Site. However, if any ERM Contractor commences work at the Site, the ERM Contractor shall be deemed to have accepted the HASP and the terms hereof and the failure to execute and return to ERM a copy of this notice shall not be relevant to such interpretation.

If a contractor or a person other than the Client, ERM employees and ERM Contractors (individually, a "Third Party" and collectively, "Third Parties") receives a copy of the HASP, such Third Party should not assume that the HASP is appropriate for the activities being conducted by the Third Party.

NO THIRD PARTY HAS THE RIGHT TO RELY ON THE HASP. EACH THIRD PARTY SHOULD ABIDE BY ITS OWN SITE-SPECIFIC HEALTH AND SAFETY PLAN IN ACCORDANCE WITH ITS OWN PROFESSIONAL JUDGMENT AND ESTABLISHED PRACTICES.

ERM shall not be responsible for the implementation of any Third Party safety program(s), except to the extent otherwise expressly agreed upon by ERM and a Third Party in writing. The services performed by ERM for the Client and any right of the client and/or an ERM Contractor to rely on the HASP shall in no way inure to the benefit of any Third Party, including, but not limited to, employees, agents, or consultants and subcontractors of ERM Contractors, so as to give rise to any cause of action by such Third Party against ERM.

The HASP generated by ERM in connection with the Project is for use on a specific site and in connection with a specific project. ERM makes no representation or warranty as to the suitability of the HASP for reuse on another site or as to the suitability of the HASP for reuse on another project or for modifications made by the Client or a Third Party to the HASP.

1.1 *SITE NAME AND ADDRESS*

Motorola 52nd Street Superfund Site
Operable Unit 3 (OU3) Study Area
Phoenix, Arizona

The Study Area is located in the eastern portion of the Phoenix Metropolitan Area that has been developed as an urban area with various commercial and residential developments.

The OU3 Study Area with proposed well locations is presented as Figure 1-1.

2.0 ERM PROJECT PERSONNEL AND RESPONSIBILITIES

ERM Partner-in-Charge (PIC): Robert Livermore –
Responsible for all work and conducts ultimate Quality Assurance/Quality Control (QA/QC) overview.

ERM Project Manager (PM): David Abranovic, P.E. –
Manages day-to-day activities; reports to PIC.

ERM Project Health and Safety Officer (HSO): Ron Brazeal –
Directs development of HASP; provides technical advice on health and safety issues.

ERM Site Safety Officer(s) (SSO): Ron Brazeal, Jason Hilker, and Adam Nagle –
Responsible for implementation of HASP during field activities; reports to PIC and PM.

3.0 SITE DESCRIPTION

This section briefly summarizes the Motorola 52nd Street Superfund Site history, describes the previous investigations conducted in the OU3 Study Area, and outlines the physical setting of the site.

The Motorola 52nd Street Superfund Site is approximately 7,800 acres and consists of three adjoining groundwater OUs: OU1, OU2, and OU3. OU1, approximately 1,000 acres, is the easternmost OU and contains the former Motorola 52nd Street semiconductor plant. The boundaries of OU1 are 52nd Street to the east, Palm Lane to the north, Van Buren Street to the south, and 44th Street to the west.

OU2 is approximately 3,800 acres, lies west of OU1, and contains the OU2 Groundwater Extraction System and several OU2 PRP facilities, including the Honeywell International (Honeywell) 34th Street facility. The approximate boundaries of OU2 are McDowell Street to the north, 44th Street to the east, Buckeye Road to the south, and the OU2 Groundwater Extraction System and 20th Street to the west.

OU3 is approximately 3,000 acres and lies west of OU2. The boundaries of the OU3 Study Area are McDowell Road to the north, the OU2 Groundwater Extraction System and 20th Street to the east, Buckeye Road to the south, and 7th Avenue to the west. The USEPA is the lead regulatory agency for OU3 and the OU2 Groundwater Extraction System. The ADEQ is the lead regulatory agency for OU1 and OU2.

A map illustrating the nearest hospital to the OU3 site is included in the red tabbed Appendix A – Map to Hospital.

4.0 FIELD ACTIVITIES

Major Job Tasks/Activities

1. Soil sampling and geologic logging;
2. Groundwater well construction and development;
3. Vapor well construction and sampling;
4. Groundwater sampling; and
5. Aquifer testing.

Task Hazard Analysis (THA) forms will be completed for the above referenced tasks as risk management tools. The forms are presented in Appendix B.

Site Personnel Job Tasks

Technical Personnel - This group includes the ERM personnel serving in various supervisory and data collection functions ranging from field management to field oversight and inspection to sample collection.

Other various contractors will be considered in the HASP as technical support personnel for tasks listed above.

5.0 HAZARD IDENTIFICATION CONTROL

5.1 HAZARD IDENTIFICATION PROCESS

Prior to initiating any new project activity or when there is a change in site conditions, the SSO will assist project team members in completing a THA form for that activity. A copy of the THA form is located in Appendix B.

5.2 CHEMICAL HAZARDS

Chemicals may be introduced into the body by ingestion, inhalation, or absorption through the skin. Since not all chemicals have the same level of toxicity, the length of time for the exposure and the concentration of the chemical(s) are important in determining the risk. Inhalation and skin contact are the most common routes of entry. Chemicals can be introduced into the body by ingestion when chemicals present on the hands are transferred to food, beverages, or tobacco.

Based on historical soil and groundwater sampling, the following potential site related listed in Table 5-1 may be encountered at the site. Toxicology Profiles for the primary chemicals of concern are located in Appendix C.

Table 5-1 Potential Site Related Chemicals

Potential Chemical Hazards

CONSTITUENT	IP[1]	TLV[2] 8-HOUR TWA	PEL[3] 8-HOUR TWA	IDLH[4] LEVEL	FLAMMABLE RANGE (percent)	ODOR THRESHOLD (ppm)	NOTES[5]	POTENTIAL SYMPTOMS OF EXPOSURE[6]
Benzene	9.24	0.5 ppm	1 ppm	500 ppm	1.2-7.8	4.68	Ca, 65	Irritation to eyes, nose, respiratory system, giddiness, headache, nausea, staggered gait, fatigue, anorexia, lassitude, dermatitis, bone marrow, depression; (potential occupational carcinogen)
Ethylbenzene	8.76	100 ppm	100 ppm	800 ppm	0.8-6.7	0.25-200		Irritation to eyes, muscle membranes, headache, dermatitis, narcosis, coma
Methane	12.48	NA	NA	Not <19.5%O_2	5.0-15.0	None		Explosive, flammable gas, simple asphyxiant
PAHs[7]	NA	50 mg/m^3	0.2 mg/m^3	500 ppm [80 mg/m^3]	0.9-5.9	NA		Irritation to eyes, skin, respiratory system. carcinogen: lung, skin
Toluene	8.82	50 ppm	200 ppm	500 ppm	1.1-7.1	0.17-40		Fatigue, weakness, confusion, euphoria, dizziness, headache, dilated pupils, lassitude, nervousness, muscle fatigue, insomnia, paresthesia, dermatitis

Potential Chemical Hazards

CONSTITUENT	IP[1]	TLV[2] 8-HOUR TWA	PEL[3] 8-HOUR TWA	IDLH[4] LEVEL	FLAMMABLE RANGE (percent)	ODOR THRESHOLD (ppm)	NOTES[5]	POTENTIAL SYMPTOMS OF EXPOSURE[6]
p-Xylene	8.56	100 ppm	100 ppm	900 ppm	1.1-7.0	0.05-200		Dizziness, drowsiness, excitement, incoherence, staggered gait, irritation to eyes, nose, throat, corneal vacuolization, anorexia, nausea, vomiting, abdominal pain, dermatitis
Chloroethane/Ethyl Chloride (CA)	10.97	100 ppm	1000 ppm	3800 ppm	3.8-15.4	4.2		Uncoordinated inebriation; abdominal cramps; cardiac arrhythmias; liver, kidney damage
1,1-Dichloroethane (1,1-DCA)	11.06	100 ppm	100 ppm	3000 ppm	5.4-11.4	120-200		Irritation to skin, central nervous system depressant, liver, kidney, lung damage
1,2-Dichloroethane (1,2-DCA)	11.05	1 ppm	50 ppm	50 ppm	6.2-16	12-100	Ca	Irritation to eyes, corneal opacity; central nervous system depressant; nausea, vomit; dermatitis; liver, kidney, cardiovascular system damage; (potential occupational carcinogen)

Potential Chemical Hazards

CONSTITUENT	IP[1]	TLV[2] 8-HOUR TWA	PEL[3] 8-HOUR TWA	IDLH[4] LEVEL	FLAMMABLE RANGE (percent)	ODOR THRESHOLD (ppm)	NOTES[5]	POTENTIAL SYMPTOMS OF EXPOSURE[6]
1,1-Dichloroethylene (1,1-DCE)	10.00	200 ppm	200 ppm	ND	6.5-15.5	–	Ca	Irritation to eyes, skin, throat; dizziness, headache, nausea; dyspnea; liver, kidney, dysfunction; pneumonia; (potential occupational carcinogen)
cis-1,2-Dichloroethylene (cis-1,2-DCE)	9.65	200 ppm	200 ppm	1000 ppm	9.7-12.8	–		
trans-1,2-Dichloroethylene (trans-1,2-DCE)	9.65	200 ppm	200 ppm	1000 ppm	9.7-12.8	17		
Tetrachloroethylene (PCE)	9.32	25 ppm	100 ppm	150 ppm	NA	1.0	Ca	Irritation to eyes, nose, throat; nausea; flush face, neck; vertigo, dizziness, uncoordinated, headache, somnolence; skin erythema; liver damage; (potential occupational carcinogen)
1,1,1-Trichloroethane (1,1,1-TCA)	11.00	350 ppm	350 ppm	700 ppm	7.5-12.5	120-500		Irritation to eyes, skin; headache, lassitude, central nervous system depressant; poor equilibrium; dermatitis; cardiac arrhythmias; liver damage

Potential Chemical Hazards

CONSTITUENT	IP[1]	TLV[2] 8-HOUR TWA	PEL[3] 8-HOUR TWA	IDLH[4] LEVEL	FLAMMABLE RANGE (percent)	ODOR THRESHOLD (ppm)	NOTES[5]	POTENTIAL SYMPTOMS OF EXPOSURE[6]
1,1,2-Trichloroethane (1,1,2-TCA)	11.00	10 ppm	10 ppm	100 ppm	8.4-13.3	0.5-167	Ca	Irritation to eyes, nose; central nervous system depressant; liver, kidney damage; dermatitis; (potential occupational carcinogen)]
Trichloroethylene (TCE)	9.45	50 ppm	100 ppm	1000 ppm	8-10.5	100	Ca	Irritation to eyes, skin; headache, vertigo; visual disturbance, fatigue, giddiness, tremor, somnolence, nausea, vomit; dermatitis; cardiac arrhythmias; paresthesia; liver injury; (potential occupational carcinogen)
Vinyl Chloride/Chloro-ethene (CE)	9.99	1 ppm	1 ppm	ND	3.6-14.8	4.2	Ca	Weak; abdominal pain, gastrointestinal bleeding; enlarged liver; pallor or cyanosis of extremities; liquid: frostbite, (potential occupational carcinogen)

Potential Chemical Hazards

CONSTITUENT	IP[1]	TLV[2] 8-HOUR TWA	PEL[3] 8-HOUR TWA	IDLH[4] LEVEL	FLAMMABLE RANGE (percent)	ODOR THRESHOLD (ppm)	NOTES[5]	POTENTIAL SYMPTOMS OF EXPOSURE[6]
1,4-Dioxane	9.13	1 ppm	100 ppm	500 ppm	2.0-22	24	Ca	Irritation to eyes, skin, nose, throat; drowsiness, headache, nausea, vomit, liver damage, kidney failure, (potential occupational carcinogen)

[1] Ionization potential in electron-volts (eV).
[2]Threshold Limit Value as the airborne 8-hour time-weighted average (TWA) established by the American Conference of Governmental Industrial Hygienist (ACGIH), 1999.
[3]Permissible Exposure as the airborne 8-hour time-weighted average (TWA) established by the Occupational Safety and Health Administration (OSHA).
[4]Immediately Dangerous to Life and Health level as published in the National Institute for Occupational Safety and Health (NIOSH), Pocket Guide to Chemical Hazards, 1994 edition.
[5]Hazard category; Ca-Carcinogen; C-Ceiling; S-Skin absorption; 65 – Proposition 65 chemicals known to the State of California to cause cancer or reproductive harm.
[6]Sources: NIOSH Pocket Guide to Chemical Hazards, June, 1994; Amdur, Mar O; Doull, John; Klaassen, Curtis, D., Toxicology, The Basic Science of Poisons, fourth Edition, 1993; and Merk & Co. Inc. The Merk Index, 1996.
[7]May include the following constituents: Acenaphthene, Acenapthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, and Pyrene.

Notes: NA = Not applicable or not available
ND = Not determined
ppm = parts per million
mg/m^3 = milligrams per cubic meter
PAHs = Polynuclear aromatic hydrocarbons

The following chemicals are routinely used by ERM and subcontractors at the site. Pertinent health and safety information for these chemicals is summarized in Table 5-2.

Table 5-2 Chemicals Typically Used In Site Investigation Activities

• Lubricants	• Portland Cement
• Liquinox	• Bentonite
• Gasoline	• Silica Sand
• Diesel	• Isobutylene Balance Air (calibration gas)

Electronic copies of Material Safety Data Sheets (MSDSs) are available on-line.

5.3 *AMBIENT AIR MONITORING*

Ambient air monitoring should be conducted by the SSO when there is a question of employee exposure to hazardous concentrations of substances to assure the proper selection of engineering controls, work practices, and personal protective equipment (PPE). Additional monitoring should be conducted under any of the following circumstances.

- Work begins on a different portion of the site;
- Change in job tasks;
- Change in weather;
- Change in ambient levels of hazardous constituents as indicated by the sense of smell or changes in the physical appearance of the soil or groundwater;
- When new hazardous substances are encountered; and
- During high-risk operations (e.g. drum opening, or handling of leaking drums, or when working in areas with obvious liquid contamination).

Ambient air monitoring will be conducted using direct-reading, real-time instruments as indicated in Table 5-3. If more that one instrument is listed, either instrument may be chosen. Not all work at the site will require ambient air monitoring for all contaminants. During the mobilization phase of a particular project task or activity, either the PM or the SSO will determine what contaminants may be encountered in order to have the appropriate instrumentation on-site. The Project Health and Safety Consultant is available to assist the PM or the SSO in determining the appropriate instrumentation. Ambient air monitoring forms for field documentation are presented in Appendix D.

Table 5-3 Ambient Air Monitoring Instruments

Contaminant	*Instrument*
VOCs	OVM Model 580B with 10.6 eV lamp or MiniRae 2000 with 10.6 eV lamp (Remember, straight chain hydrocarbons do not register well on PID units and a FID may be required).

Direct reading instrumentation will be calibrated daily per manufacturer's instructions. Cylinders of the appropriate calibration gas will be required for fieldwork lasting longer than one day.

Under stable site conditions, ambient air monitoring will be conducted at least once every two hours in the workers' breathing zone and at other locations based on the professional judgment of the SSO or the Project Health and Safety Consultant. Ambient air monitoring results will be recorded on the Ambient Air Monitoring Form found in Appendix D. If site conditions become unstable or change dramatically, ambient air monitoring will be conducted more frequently based on the professional judgment of the SSO or the Project Health and Safety Consultant.

Table 5-4 outlines the steps to be taken by the SSO when the action levels of the various contaminants are exceeded. Respiratory protection is selected based on occupational exposure limits of the constituents at the site and the potential for exposure to vapors and dust from site activities.

Table 5-4 Action Levels and Response Actions Requirements

Chemical	*Action Level*	*Response Actions*
VOCs	PID reads 5 ppm sustained in the breathing zone for 1 minute	• Stop work and workers leave immediate area • SSO evaluates need for Tyvek coveralls, dons half-face respirator with organic vapor cartridges and monitors again after allowing vapors to dissipate. • If readings are less than 5 ppm, resume work. • If readings are 5 ppm or greater, resume work wearing half-face respirators with organic vapor cartridges.
	PID reads 10 ppm sustained in the breathing zone for 1 minute	• Stop work and workers leave immediate area. • Contact PM and Project Health and Safety Consultant. • Evaluation work practices and assess engineering controls to reduce airborne concentrations. • SSO waits 15 minutes, evaluates need for Tyvek covers, dons half-face respirator with organic vapor cartridges, approaches work area slowly, if PID reaches 5 ppm, back out and wait an additional 15 minutes before repeating monitoring.

6.0 *PERSONAL PROTECTIVE EQUIPMENT*

The level of PPE selected for a task is based on the following:

- Type and measured concentration of the chemical substance in the ambient atmosphere and its toxicity;
- Potential for exposure to substances in air, splashes of liquids, or other direct contact with material due to work being done; and
- Knowledge of chemicals on-site along with properties such as toxicity, route of exposure, and contaminant matrix.

In situations where the type of chemical, concentration, and possibilities of contact are not known, the appropriate level of protection must be selected based on professional experience and judgment until the hazards can be better identified.

In addition to summarizing the general PPE requirements for tasks performed at the site, Table 6-1 also serves as the written certification that the PPE Hazard Assessment has been conducted. The signature page containing the client's name, project name and number, date, and signatures of the parties responsible for the development of the HASP also serve as part of the written certification.

6.1 *RESPIRATORY PROTECTION*

Respiratory protection is not anticipated, however the type of respiratory protection required will be based on the results of ambient air monitoring, the results of any models used to predict ambient air concentrations, and the professional judgment of either the SSO or the Project Health and Safety Consultant. Respiratory protection requirements are outlined in Table 6-1.

As required by 29 CFR 1910.134, Respiratory Protection, a cartridge change-out schedule will be developed based on the results of ambient air monitoring. Ambient air monitoring forms are presented in Appendix D.

Table 6-1 Personal Protection Equipment Requirements

PPE Level	*Ensemble Components*	*Anticipated Use*
Level D Should be worn only as a work uniform and not in any area with respiratory or skin hazards. It provides minimal protection against chemical hazards.	• Long pants and shirt with sleeves. • Safety-toed footwear. • Safety glasses with molded side shields. • Hard hat. • General purpose work gloves if task does not involve water or wet materials. • Hearing protection. • High visibility traffic vest.	• Drilling. • Groundwater gauging/sampling. • Vapor sampling. • Pump Test.
Modified Level D	Level D and the following: • Disposal Tyvek coveralls (if splash potential). • Thin nitrile gloves. • Green nitrile gloves over thin nitrile gloves when primary gloves may tear or puncture.	***Any of the above-referenced tasks in which there is moderate potential for skin contact.*** ***Soil and groundwater sampling tasks.***
Level C Should be worn when the criteria for using air-purifying respirators are met, and a lesser level of skin prot1ection is needed.	Level D or Modified Level D and the following: • Half-face air purifying respirator with combination organic vapor/high efficiency particular air (HEPA) cartridges.	Any of the above-referenced tasks in which there is moderate potential for skin contact with constituents and data indicating need for respiratory protection.
Level B Should be worn when the highest level of respiratory protection is needed, but a lesser level of skin protection is needed.	Not anticipated to be required	Tasks requiring Level B PPE are not anticipated during this project. If Level B PPE is needed, as determined by the SSO and/or the Project Health and Safety Consultant, the HASP will be revised.
Level A Should be worn when the highest level of respiratory, skin, and eye protection is needed.	Not anticipated to be required	Tasks requiring Level A PPE are not anticipated during this project. If Level A PPE is needed, as determined by the SSO and/or the Project Health and Safety Consultant, the HASP will be revised.

7.0 THERMAL STRESS

7.1 HEAT STRESS

Heat stress is caused by a combination of factors such as temperature, humidity, type of work being performed, and use of PPE including protective clothing. Heat stress tends to increase body temperature, heart rate, and sweating. The key to preventing heat stress is education of personnel relative to the hazards associated with working in the heat and implementation of proper controls and work practices. Table 7-1 summarizes heat stress disorders and prevention/first aid issues.

When the temperature is above 80° Fahrenheit (F), the SSO will monitor both the temperature and the humidity throughout the day in order to determine the Heat Index. The National Weather Service has developed a Heat Index that combines the ambient temperature and humidity into value that reflects how hot it really feels. This Heat Index can be used to determine the risk associated with working outdoors during the hot months of the year. To use the chart (Table 7-2), read the temperature at the left and humidity across the top, the Heat Index is where the two intersect. For example, with a temperature of 96°F and a humidity of 50%, the Heat Index is 108°F.

The SSO will also inform site workers when the Heat Index Risk Level, as defined on Table 7-3, reaches Danger and/or Extreme Danger. The following additional precautions may be implemented at the discretion of the SSO based on factors such as use of Tyvek coveralls and the physical activity associated with each task. The following actions or work practices will be implemented, as practical, as part of the Heat Stress Management Program.

1. Designated areas will be used for site workers to take breaks and for eating;
2. If possible, physically demanding and strenuous tasks may be scheduled for the cooler parts of the day;
3. Site workers will be required to drink 6-8 ounces of cool water or electrolyte replacement drinks every 60 minutes. Diabetics should use caution when using electrolyte replacement drinks to replenish fluids. Electrolyte replacement drinks may have high sugar content;

4. Site workers taking prescription medications should check with their doctor or other medical professional regarding the interaction between working in hot environments and their medications;
5. SSO will more closely observe site workers, especially those working in Tyvek coveralls or performing strenuous job tasks;
6. Implement worker rotation during strenuous or physically demanding job tasks; and
7. SSO will implement a work-rest cycle. (Table 7-4.)

Table 7-1 Heat Stress Disorders

Disorder	*Symptoms*	*Cause*	*Prevention/First Aid*
Heat Rash or Prickly Heat	♦ Rash ♦ Itching	♦ Hot, humid conditions ♦ Sweat doesn't evaporate easily ♦ Sweat ducts become clogged	♦ Ointments ♦ Keep skin clean and dry ♦ Good daily personal hygiene
Heat Cramps	♦ Sudden onset of muscle cramps usually in legs or arms ♦ Hot, moist skin ♦ Normal pulse ♦ Normal or slightly elevated temperature	♦ Loss of water (sweating) ♦ Loss of electrolytes ♦ Replacing water but not electrolytes	♦ Move into shade ♦ Loosen clothing ♦ Drink tepid electrolyte drinks or water ♦ Seek medical assistance if conditions persist
Heat Exhaustion	♦ Pale, clammy skin ♦ Profuse perspiration ♦ Thirst from dehydration ♦ Weakness ♦ Headache ♦ Nausea ♦ Loss of coordination	♦ Overexertion ♦ Excessive loss of water and electrolytes	♦ Move into shade ♦ Remove PPE ♦ Loosen street clothing ♦ Cool by applying damp cool compresses or ice packs ♦ Drink tepid electrolyte drinks or water ♦ Summon medical assistance

Disorder	*Symptoms*	*Cause*	*Prevention/First Aid*
Heat Stroke	♦ Elevated temperature (>103F) ♦ Flushed, hot, dry skin ♦ Absence of sweating ♦ Delirious ♦ Rapid pulse ♦ Nausea ♦ Headache ♦ Dizziness ♦ Unconsciousness	♦ Failure of body's cooling (sweating) mechanism	♦ Summon medical assistance ♦ Move to shade ♦ Remove PPE ♦ Loosen street clothing ♦ Cool by fanning or applying damp compress or ice packs

Table 7-2 Heat Index Chart

Relative Humidity (%)														
Temperature (F)		**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
	110	136												
	108	130	137											
	106	124	130	137										
	104	119	124	131	137									
	102	114	119	124	130	137								
	100	109	114	118	124	129	136							
	98	105	109	113	117	123	128	134						
	96	101	104	108	112	116	121	126	132					
	94	97	100	102	106	110	114	119	124	129	136			
	92	94	96	99	101	105	108	112	116	121	126	131		
	90	91	93	95	97	100	103	106	109	113	117	122	127	132
	88	88	89	91	93	95	98	100	103	106	110	113	117	121
	86	85	87	88	89	91	93	95	97	100	102	106	108	112
	84	83	84	85	86	88	89	90	92	94	96	98	100	103
	82	81	82	83	84	84	85	86	88	89	90	91	93	95
	80	80	80	81	81	82	82	83	84	84	85	86	86	87

Table 7-3 Heat Index Risk Level and Associated Health Effects

Heat Index	Associated Risk
>130	*Extreme Danger* Heat stroke highly likely with continued exposure
105-130	*Danger* Heat exhaustion and heat cramps likely and heat stroke possible with prolonged exposure and/or physical activity
90-105	*Extreme Caution* Heat cramps and heat exhaustion possible with prolonged exposure and/or physical activity
80-90	*Caution* Fatigue possible with prolonged exposure and/or physical activity

NOTES:

- Heat Index values were devised for shady, light wind conditions. Exposure to full sun may increase these values by up to 15°.
- Heat Index values were devised for the general public wearing typical lightweight summer clothing. Acclimatized workers may be able to work under conditions with a slightly higher Heat Index.
- The use of personal protective equipment, including clothing increases the heat stress load on the body.

The work-rest cycle outlined below may be implemented based on the professional judgment of the SSO and/or the Project Health and Safety Consultant.

Table 7-4 ***Work-Rest Cycle***

Heat Index	Risk Level	Work-Rest Cycle
> 130	Extreme Danger	15 minute break every 30 minutes
105-130	Danger	15 minute break every 60 minutes
90-105	Extreme Caution	15 minute break every 90 minutes
80-90	Caution	15 minute break every 120 minutes

7.2 COLD STRESS

Cold stress situations may be encountered at the site. If lower than normal temperatures (i.e., less than 35°F) are forecasted the following information will be utilized. Most cold related worker fatalities have resulted from failure to escape low environmental air temperatures, or from immersion in low temperature water. The two most prominent adverse effects from exposure to cold temperatures are frostbite and hypothermia. A person qualified in first aid or a professional medical provider should administer treatment for cold related injuries. The single most important aspect of life-threatening hypothermia is a drop in the deep-core body temperature.

Frostbite

Frostbite occurs when the extremities do not get sufficient heat from the central body stores. The fluids around the cells of the body tissues freeze from exposure to low temperatures. This condition can result in damage to, and loss of, tissue. The most vulnerable areas are the nose, cheeks, ears, fingers, and toes. Damage from frostbite can occur in either the outer layers of skin or in the tissue beneath these layers and can be serious, resulting in scarring, tissue death, permanent loss of movement, or amputation.

Hypothermia

This is the most severe form of cold stress and results from a drop in the body's core temperature. Hypothermia can occur in relatively mild temperatures if there is a wind and the person's clothing becomes wet. The symptoms of hypothermia are:

- First, uncontrollable shivering and the sensation of the cold;
- Heartbeat slows and may become irregular;
- Pulse weakens and blood pressure changes;
- As the body's core temperature drops, other signs may include cool skin, slow irregular breathing, and apparent exhaustion;
- When core temperatures are in the mid-range, the victim may become listless, confused, exhibit severe shivering, or develop severe pain in the extremities; and
- Final signs are a significant drop in blood pressure, fatigue, and shallow respiration.

Control Measures for Cold Stress

Worker comfort will be monitored and increased layers of PPE or clothing worn under the PPE may be required to minimize cold stress for those persons working inside a building. For those workers performing tasks outside a building when ambient temperature falls below 36ºF, the following guidelines should be used:

- If wind chill is a factor, shielding the work area or providing employees an outer windbreak layer garment will reduce the cooling effect of the wind;
- Extremities, ears, toes, and nose will be protected from extreme cold by protective clothing;
- Employees performing light work and whose clothing may become wet will wear an outer layer of clothing that is impermeable to water;
- Employees performing moderate to heavy work and whose clothing may become wet will wear an outer layer of clothing that is water repellent; and
- Outer garments must provide for ventilation to prevent wetting of inner clothing by sweat.

Workers who become immersed in water or whose clothing becomes wet will immediately be provided a change of clothing and be treated for hypothermia if necessary. If the clothing becomes wet from sweating, the employees may finish the task that caused the sweating before changing into dry clothes. Metal handles of tools and control bars will be covered by thermal insulating materials when temperatures fall below 30ºF. Whenever a site becomes covered with snow or ice, eye wear will be worn by employees for protection against ultraviolet light, glare, and blowing ice crystals.

When conducting work in air temperatures below 35º F, the following practices shall be followed:

- If the clothing of an employee is expected to become wet, the outer layers of clothing must be impermeable to water;
- If an employee's underclothing becomes wet it must be changed immediately. If the clothing becomes wet from sweating, the employee may finish the task that caused the sweating before changing into dry clothing;
- Employees will be provided a warm area (65ºF or above) to change from work clothing into street clothing and for breaks;
- Hot liquids, such as soups, warm drinks, etc. shall be provided in the break area. The intake of caffeine containing products shall be discouraged due to their diuretic and circulatory effects;
- If appropriate, approved space heaters may be provided in the work area to warm the hands, feet, etc.;
- The buddy system shall be practiced. Any employee observed with signs of cold stress shall immediately proceed to the break area;
- Employees will be reminded to layer their clothing, (i.e., wear thinner, lighter clothing next to the body with heavier clothing layered outside the inner clothing);
- Avoid overdressing when going into warm areas or when performing activities that are strenuous. This could potentially lead to heat stress situations;
- Auxiliary heated versions of hand wear, footwear, etc., can be used in lieu of mittens, insulated socks, etc. if extremely cold conditions exist;

- Employees handling liquids with high evaporation rates (gasoline, hexane, alcohol, etc.) shall take special precautions to avoid soaking of clothing with the liquids because of the added danger of cold injury caused by evaporative cooling;
- Work shall be arranged in such a way that sitting still or standing for long periods is minimized; and
- If the air temperature is 20ºF or below the hands shall be protected by mittens or gloves prior to contact with cold surfaces such as metal, etc.

Air temperature is not the only factor to be considered while evaluating cold stress situations. Wind chill cooling rate and the cooling power of air are critical factors. The higher the wind speed the greater the risk of experiencing cold related injuries. For exposed skin, continuous exposure should not be permitted when the air speed and temperature result in an equivalent chill temperature of -25ºF or less.

8.0 CLIENT SPECIFIC REQUIREMENTS

The client does not have any specific requirements outside of the CFR 1910.120 requirement for the work governed by this HASP and the Administrative Settlement Agreement and Order on Consent Docket No. 2008-17, USEPA Region IX.

9.0 SAFE WORK PRACTICES AND STANDARD OPERATING PROCEDURES

9.1 GENERAL SAFE PROVISIONS

9.1.1 *Smoking and Eating Areas*

Smoking will only be allowed in designated areas. Upon mobilization at the site, the SSO will establish smoking areas per site-specific or client-specific requirements. Individuals caught smoking outside the designated smoking areas will be subject to disciplinary action up to and including immediate termination.

Upon mobilization at the site, the SSO will establish eating and break areas per site-specific or client-specific requirements. Eating will only be allowed in the designated areas and the areas will be maintained in a clean and sanitary condition.

9.1.2 *Sanitation and Potable Water*

Containers used for drinking water will be equipped with a tap and capable of being tightly closed. In addition, the container will be labeled as "Drinking Water" or "Potable Water." Disposal cups will be stored in a sanitary condition and a receptacle for disposing of the cups will be nearby.

Potable and non-potable water containers and portable toilets will comply with OSHA 29 CFR 1910.141 requirements.

Pre-moistened towels, such as baby wipes, and/or potable water and soap will be available for hand washing.

9.1.3 *Temporary Facilities*

Trailers and other temporary structures used as field offices or for storage will be anchored with rods and cables or by steel straps to ground anchors. The anchor system will be designed to withstand winds and must meet applicable state or local regulations for the anchoring of mobile trailer homes.

All temporary facilities will be maintained in a clean and sanitary condition to discourage the entrance of rodents or vermin. If rodents or vermin become an issue, the SSO will be responsible for implementing an extermination program per site-specific or client-specific guidelines.

9.2 STANDARD OPERATING PROCEDURES

The following standard operating procedures will be adhered to at all times:

1. All personnel entering the site must check in with the SSO.
2. All individuals entering the site must demonstrate to the SSO that they have been adequately trained as defined in Section 10.
3. All individuals must be familiar with emergency communication methods and how to summon emergency assistance.
4. Use of alcoholic beverages before, during operations, or immediately after hours is absolutely forbidden. Alcohol can reduce the ability to detoxify compounds absorbed into the body as the result of minor exposures and may have negative effects with exposure to other chemicals. In addition, alcoholic beverages will dehydrate the body and intensify the effects of heat stress.
5. Horseplay of any type is forbidden.
6. All unsafe conditions will be immediately reported to the SSO, who will document such conditions in the field log. The SSO will be responsible for ensuring that the unsafe condition is correctly as quickly as possible.
7. Smoking, matches, and lighters are only allowed in the designated smoking area.
8. Avoid contact with potentially contaminated substances. Avoid, whenever possible, kneeling on the ground, or leaning or sitting on trucks, equipment or the ground. Do not place equipment on potentially contaminated surfaces.
9. If PPE becomes damaged or saturated with potentially contaminated material, immediately replace the affected PPE. Additionally, wash any exposed skin thoroughly with soap and water.

9.3 SAFE WORK PRACTICES

9.3.1 Ergonomics

Ergonomic risk factors include repetitive motion, force, awkward posture, and vibration. The key to preventing ergonomic injuries is education of personnel relative to the hazards and risk factors, implementation of proper controls, and work practices. When completing THAs the Project Health and Safety Consultant will assist project team members in identifying ergonomic risk factors and appropriate control methods.

Several tasks associated with this project have the potential to cause back injuries if proper lifting techniques are not followed. Site workers should not lift objects that are beyond their physical capabilities. The use of mechanical devices such as forklifts is encouraged. Also, when shoveling, site workers should not twist their backs while moving materials with the shovel. The proper technique is to move the feet.

Proper lifting techniques are summarized below:

1. Place feet shoulder width apart with toes pointing slightly out;
2. Bend at your knees keeping back straight;
3. Get a good grip on the object and pull object close to your body;
4. Tighten abdominal muscles;
5. Keep your head up, looking forward, and lift with your legs while maintaining a straight back;
6. Keep load close to your body and ensure your view is not obstructed;
7. If one end of the load is heavier than the other, the heavier end should be closest to your body;
8. Move your feet to relocate the object as opposed to twisting your back; and
9. When placing the object down, bend your knees, and use your leg muscles while keeping your back straight.

9.3.2 *Pre-Drilling/Pre-Excavation and Probing Protocol*

Prior to mobilizing to the field, the Project Manger will be responsible for ensuring the ERM Subsurface Clearance Guidelines are followed, including verifying that the following issues have been adequately addressed and completing the ERM Subsurface Clearance Checklist which is presented in Appendix E.

1. Contacting the State's One Call or equivalent utility locator service to identify underground pipelines, utility lines, and fiber optic cable;
2. Contacting appropriate municipality to identify underground water and sewer lines;
3. Contacting posted pipeline companies; and
4. Contacting client to identify underground pipelines or other obstructions.

Prior to commencing drilling or excavating activities, the intended drill path will be cleared to a depth of 10 feet. The clearance of the drill path helps to ensure that the drilling or excavating activity will not hit an underground obstruction or utility line. Drill path clearance methods will be conducted by an experienced contractor using air-knife equipment which utilizes high pressure air and an associated vacuum to remove soil from the drill hole. Appropriate PPE, which includes face shields, will be utilized by contractors and ERM personnel during the clearance activities. Reference the Task Hazard Analysis in Appendix B.

9.3.3 *Fall Protection*

This project does not involve working from heights more than 6-feet above grade.

However, in the event that project team members and/or subcontractors are working more than 6-feet above grade, and are not protected by handrails, complete floor decking, or working on approved access ways, fall protection equipment will be required.

The distance above grade is measured from the employee's feet to the grade or approved work surface. Fall protection equipment will consist of

an American National Standards Institute (ANSI)-approved full-body harness and shock-absorbing lanyard with double-locking D-rings.

Acceptable anchor points to which the lanyard may be attached includes, but is not limited to, the following:

- Structural beams at least 6-inches in depth for one or more persons in a completed structure;
- Pipes at least 4-inches in diameter for one person;
- Pipes at least 6-inches in diameter for two people;
- Nozzles at least 3 inches for one person;
- Nozzles greater than 3 inches for two people; and
- Permanent platform handrail post below mid-rail for one person.

9.3.4 *Weather-Related Events*

Weather-related events that may impact field work are mostly associated with the summer monsoons, and includes rain, thunder, lightning, flash flooding, and strong winds. The SSO will be responsible for determining what site work can be performed safely in the rain, and at what point work will cease due to either quality or safety issues. In the event of thunder and/or lightning, all work will be suspended until 15 minutes have elapsed from the last clap of thunder or flash of lightning. (These are minimum guidelines. The National Lightning Safety Institute publishes guidelines on their website as reprinted below.)

Lightning Safety for Outdoor Workers

Safety and productivity are not mutually compatible, so one must be chosen over the other. Easy choice: SAFETY FIRST! Lightning has visited most all outdoor work environments. Anticipate a high-risk situation and move to a low-risk location.

Lightning safety awareness is a priority at every outdoor facility and operation. Education is the single most important means to achieving lightning safety. The following steps are suggested:

1. Monitor weather conditions in the early morning hours. Local weather forecasts – from The Weather Channel or NOAA Weather Radio – should be noted 24 hours prior to scheduled activities. An inexpensive

portable weather radio is recommended for obtaining timely storm data.

2. Suspension and resumption of work activities should be planned in advance. Understanding of SAFE shelters is essential. SAFE evacuation sites include:
   - Fully enclosed metal vehicles with windows up;
   - Substantial buildings;
   - Low ground – seek cover in clumps of bushes; and
   - Trees of uniform height, such as a forest.
3. UNSAFE SHELTER AREAS include all outdoor metal objects, like power poles, fences and gates, high mast light poles, metal bleachers, electrical equipment, mowing, and road machinery. AVOID solitary trees. AVOID water. AVOID open fields. AVOID high ground and caves.
4. Lightning's distance from you is easy to calculate: If you hear thunder, the associated lightning is within audible range, about 6-8 miles away. The distance from Strike A to Strike B also can be 6-8 miles. Suspend activities, allowing sufficient time to get to shelter. Of course, different distances to safety will determine different times to suspend activities. A good lightning safety motto is:

   "If you can see it (lightning), flee it;
   if you can hear it (thunder), clear it."
5. If you feel your hair standing on end, and/or hear "crackling noises," you are in lightning's electric field. If caught outside during close-in lightning, immediately remove metal objects (including baseball cap), place your feet together, duck your head, and crouch down low in baseball catcher's stance with hands on knees.
6. Wait a minimum of 30 minutes from the last observed lightning or thunder before resuming activities. Be extra cautious during this phase as the storm may not be over.
7. People who have been struck by lightning do not carry an electrical charge and are safe to handle. Apply first aid immediately if you are qualified to do so. Get emergency help promptly.
8. During rain, lightning and/or thunder events, site workers should seek shelter in either a building or vehicle. In the event of a tornado, site workers should seek shelter in a building, except trailers, or in a low-lying area.

9.3.5 *Night Work*

When work is performed at night, temporary lighting must be provided. Active work areas are to be lighted to a minimum of three-foot candles. The SSO will evaluate the work areas using an Extech Light Meter or equivalent.

Other precautions that may be necessary include the following:

1. Protect lamps from breakage;
2. Provide barricades, hand or mechanical signals, stop logs, reflecting horses, post appropriate signage;
3. Post a guard as necessary;
4. Use reflective clothing or strobe lights for personnel working on the ground;
5. Alert employee/workers to potential hazards, particularly those that may not be easily seen due to night conditions;
6. Monitor area to ensure adequate lighting of work area; and
7. Provide a communication system (e.g., radios or walkie-talkies) to employees/workers.

9.3.6 *Noise*

Employees performing any noisy task, such as but not limited to, operating heavy equipment, using power tools, or employees working within 20 feet of the person performing the task will wear hearing protection consisting of either earplugs or earmuffs. Personnel operating a drilling rig or standing within 20 feet of a drilling rig during operation will also wear hearing protection.

10.0 EMPLOYEE TRAINING

All employees and subcontractors working on-site, who may be exposed to hazardous substances, health hazards, or safety hazards and their supervisors and management responsible for the site will receive training meeting the requirements of 29 CFR 1910.120 or 29 CFR 1926.65 (as applicable), Hazardous Waste Operations and Emergency Response (HAZWOPER) before they are permitted to engage in any job task. Employees will not be permitted to participate in or supervise field activities until they have been trained to a level required by their job function and responsibility. Once on-site, all site workers will receive training covering at a minimum the following:

- Names of personnel and alternates responsible for site safety and health;
- Safety, health, and other hazards present on the site;
- Use of PPE;
- Work practices by which the employee can minimize risks from hazards;
- Safe use of engineering controls and equipment on the site; and
- Medical surveillance requirements including recognition of symptoms and signs which might indicate overexposure to hazards.

10.1 SUBCONTRACTOR TRAINING

The SSO will verify that subcontractor personnel have received all appropriate training as required by this HASP prior to their arriving on-site. Verification will consist of reviewing written training documentation such as copies of training certificates or cards issued by a Contractor Safety Council provided by the subcontractor. Copies of the written training documentation will be retained in the project file. Subcontractor personnel will not be allowed to work at the site unless said training documentation is available.

10.2 DAILY TAILGATE SAFETY MEETING

A tailgate safety meeting will be conducted each morning. The daily safety meeting meetings will include awareness concerns such as special concerns regarding health and safety, pollution prevention, and/or a discussion of recent incidents or safety observations. Issues, such as any changes to the HASP or THAs and comments from the project personnel will be addressed daily. The meetings will include a discussion of what tasks will be completed that day and how those tasks will be conducted safely. The meetings will be documented on the Daily Safety Meeting form found in Appendix F.

11.0 MEDICAL SURVEILLANCE

All ERM employees are enrolled in a medical surveillance program. All employees receive an initial medical examination and consultation prior to assignment to any job site. In addition, employees receive an annual medical examination, a medical examination upon termination of employment, a medical examination when the employee exhibits signs or symptoms relating to possible overexposure to hazardous substances, or when an injury or exposure above published exposure limits has occurred in an emergency situation.

Additional medical surveillance should be provided for employees who:

1. Are or may be exposed to hazardous substances or health hazards at or above published exposure levels for these substances for 30 days or more per year;
2. Wear a respirator for 30 days or more a year or as required by 29 CFR 1910.134, Respiratory Protection; and
3. Are injured, become ill, or develop signs or symptoms due to possible exposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation.

12.0 SITE CONTROL MEASURES

1. Site work zones – Exclusion and Support Zone (see previous sections);
2. Documenting (Signing-in/signing-out) personnel at the site in the field log book;
3. Implement traffic controls required by the City of Phoenix (COP) while working in right-of-way zones. Use the COP guidance manual for right-of-way requirements (carry a copy of the manual for reference);
4. Determine if a designated person is necessary to act as a safety lookout while conducting field activities;
5. Erecting fencing/barricades around the work area; and
6. Reporting of any unauthorized personnel at the site to the client contact.

13.0 DECONTAMINATION PROCEDURES

Decontamination involves the orderly controlled removal of contaminants from both personnel and equipment. The purpose of decontamination procedures is to prevent the spreading of contaminated materials into uncontaminated areas. All site personnel should limit contact with contaminated soil, groundwater, or equipment in order to reduce the need for extensive decontamination.

Equipment and materials used in the decontamination process may include the following:

- High pressure/hot water cleaning using only potable water/fire water;
- Phosphate-free detergent;
- Five-gallon bucket;
- Potable water;
- Distilled water;
- Paper towels; and
- Brushes.

13.1 PERSONNEL DECONTAMINATION

The following decontamination procedures will be utilized:

- Remove all PPE and dispose of the PPE in the designated containers; and
- Wash hands and any skin that may have come in contact with affected soil or groundwater with moistened disposable towels, such as baby wipes, or soap and water.

PPE will be disposed of with any Investigation-Derived Wastes (IDW) such as soil or groundwater.

13.2 EQUIPMENT DECONTAMINATION

Equipment and materials used in the decontamination process may include the following:

- High pressure/hot water cleaning using only potable water/fire hydrant water;
- Decontamination water will be captured within a trough or engineered plastic covered berm area;
- Decontamination water will be transferred and containerized within 55-gallon drums which will be properly labeled and sealed;
- The drums will be stored in a secured area pending approved disposal; and
- Decontamination water will be treated as and disposed of as IDW. The decontamination water will be profiled using analytical analysis. Disposal methods may vary depending on analytical profiling results.

14.0 CONFINED SPACE ENTRY PROCEDURES

Entry into permit-required confined spaces is not anticipated.

If a project task or activity would involve entry into a permit-required confined space, or if there is a question as to whether or not a job task or activity involves a permit-required confined space, the PM or SSO will contact the Project Health and Safety Consultant for assistance.

15.0 SPILL CONTAINMENT PROGRAM

The spill contamination program for this project will involve the use of preventative measures in order to reduce the potential for environmental releases. These preventative measures will include the following:

1. Equipment inspection;
2. Staging equipment on containment pads;
3. Secondary containment for pump test storage tanks; and
4. General housekeeping practices.

If project activities involve the use of drums or other containers, the drums or containers will meet the appropriate Department of Transportation (DOT) regulations, they will be inspected, and their integrity assured prior to being moved. Operations will be organized so as to minimize drum or container movement. Drums will be properly labeled as to contents. Drums or containers that cannot be moved without failure will be overpacked into an appropriate container.

15.1 HYDRAULIC FLUID/ENGINE OIL/FUEL SPILLS

Plastic sheeting will be placed under the drill rig prior to commencing field activities to minimize the risk of fluid leaks. In the event of an unexpected release of hydraulic fluid, engine oil, gasoline, or diesel fuel, the release material will be absorbed with sorbent pads, which will be placed in a designated drum for disposal. Impacted soil will be excavated and placed on plastic sheeting and covered until characterization and/or disposal can be arranged.

16.0 SITE COMMUNICATION

Cell phones will be used for communication between the project team and the client. The SSO will create a list of cell phone numbers prior to commencing field activities. However, cell phones cannot be used in operating process units or while driving any type of vehicle. Two-way radios may be utilized for communication between project team members.

17.0 COMMUNICATION AND REVIEW OF SITE-SPECIFIC HEALTH AND SAFETY PLAN (HAZARD COMMUNICATION)

An initial review of the site-specific HASP will be held either prior to mobilization or after mobilization but prior to commencing work at the site to communicate HASP details and answer questions to individuals working at the site. Daily tailgate safety meetings will be held each morning to review work practices for the day and to discuss safety issues. Any new hazard or safety information will be disseminated at the daily tailgate safety meeting or as needed throughout the day. Daily tailgate safety meeting forms will be completed each day and are located in Appendix F.

18.0 EMERGENCY RESPONSE PLAN

This section describes possible contingencies and emergency procedures to be implemented at the site.

18.1 PERSONNEL ROLES AND LINES OF AUTHORITY

The SSO has primary responsibility for site evacuation and notification in the event of an emergency situation. This includes taking appropriate measures to ensure the safety of site personnel and the public. Possible actions may involve the evacuation of personnel from the site area and ensuring that corrective measures have been implemented, appropriate authorities notified, and follow-up reports completed. If the SSO is not available, the ERM Project Geologist/Engineer will assume these responsibilities. Subcontractors are responsible for assisting the SSO in their mission within the parameters of their scope of work.

18.2 EVACUATION ROUTES AND PROCEDURES

As work locations vary throughout the project, discuss each evacuation route, if necessary, each morning prior to commencing field activities.

In the event of an emergency, it is important to be aware of the prevailing wind direction and evacuate upwind or crosswind.

18.3 ASSEMBLY POINTS

As work locations vary throughout the project, the primary Assembly Point, in the event of an emergency, will be discussed prior to commencing field activities each day.

In the event of an emergency requiring evacuation to an Assembly Point, the SSO will be responsible to account for the presence of all project team members and subcontractors on-site at the time of the emergency.

18.4 *REPORTING EMERGENCIES*

All, including any late developing or aggravated injuries, must receive prompt medical attention. For non-life threatening injuries or illnesses site workers should be transported to the hospital. For life threatening injuries or illnesses, the local emergency responders should be contacted via ***911.***

The SSO is responsible for reporting all injuries, illnesses, fires, spills/releases, property damage, or near-misses to the following individuals:

- Injured/involved employee's supervisor;
- ERM Project Manager;
- ERM Partner-in-Charge; and
- Client Contact.

The Project Health and Safety Consultant will be responsible for notifying the ERM OpCo Health and Safety Director of the incident. In addition, the Project Health and Safety Consultant will assist in completing any incident forms and assisting with the incident investigation.

18.5 *EMERGENCY CONTACTS*

In the event of an emergency, the SSO will contact the following as appropriate.

Title/Name	*Phone Numbers*	
ERM Partner-in-Charge Robert Livermore	Work: Mobile:	480-998-2401 602-284-6495
Project Manager David Abranovic	Work: Mobile:	480-998-2401 602-284-4917
Site Safety Officer Ron Brazeal	Work: Mobile:	480-998-2401 602-541-0175
Project Geologist/Engineer Jason Hilker	Work: Mobile:	480-998-2401 602-390-1551
Client Contacts Judith Heywood	Work: Mobile:	602-250-3850 602-818-0259

Title/Name	*Phone Numbers*	
Client Contacts Troy Kennedy	Work Mobile:	973-455-4279 973-216-6787
Local Emergency Responders	Phone:	***911***
Hospital Phoenix Memorial 1201 S. 7th Avenue, Phoenix, AZ	Phone:	602-258-5111
Regulatory Contacts		
EPA Project Coordinator or Regional Duty Officer	Phone:	415-947-4400
National Response Center	Phone:	800-424-8802

Per the Consent Order, in the event of any release of a hazardous substance, ERM will notify client contacts and the EPA Project Coordinator or Regional Duty Officer at (415) 947-440 and the National Response Center at (800) 424-8802 as listed above.

18.6 INCIDENT INVESTIGATIONS

An ERM Incident Form (Appendix G) will be completed and forwarded to the Project Manager within 24 hours of an incident. All incidents will be investigated in a timely manner. The SSO and/or the Project Manager will schedule the investigation and include project supervision (ERM, subcontractors, and client), the injured/involved employee(s) and the Project Health and Safety Consultant. Root cause analysis will be performed to assess the apparent cause and identify corrective measures to be implemented to prevent re-occurrence. The last page of the Incident Form is used to document the investigation. Per requirements in the Consent Order (Docket No. 2008-17, USEPA Region IX), in the event of any release of a hazardous substance, ERM shall submit a copy of the incident report to EPA Region IX within seven (7) days after such release.

18.7 DIRECTIONS TO NEAREST HOSPITAL

Due to the various locations of project tasks, directions to the nearest hospital will be discussed at each morning tailgate meeting. A specific route is not relevant to this type of project. The hospital identified for the project is the Phoenix Memorial Hospital located at 1201 South 7th Avenue, Phoenix, Arizona. Additionally, St. Luke's Medical

Center is located at 1800 East Van Buren Street, Phoenix, Arizona. A map identifying the hospital locations are located in Appendix A.

18.8 EMERGENCY DRILLS

In accordance with the HAZWOPER Standard, emergency response plans will be rehearsed regularly as part of the overall training program for site operations. Drills do not need to be elaborate. A table-top scenario during the daily safety meeting is an adequate drill.

Table 18-1: Emergency Drill Frequency

Project Duration	*Drill Frequency*
Less than 30 days	None, cover during review/sign-off of HASP
Greater than one month but less than one year	Once
Greater than one year	Annually

19.0 SAFETY EQUIPMENT

A first aid kit containing first aid items for minor incidents only and a fire extinguisher is maintained in each ERM vehicle. Each piece of heavy equipment will have a fire extinguisher on board. Make modifications to the location of fire extinguishers as dictated by the project.

The SSO will be responsible for ensuring that all fire extinguishers are inspected monthly as required by 29 CFR 1910.157 Portable Fire Extinguishers. The monthly inspections will be documented on a tag attached to each extinguisher or a master list of fire extinguishers and their location. If the duration of the project exceeds one year, the SSO will contract with an outside vendor to perform the annual maintenance on all fire extinguishers.

20.0 CERTIFICATION OF FAMILIARITY WITH PLAN BY SITE PERSONNEL

By signing below, signee certifies that they have read, understand and will abide by the contents of this HASP.

Name	*Signature*	*Company*	*Date*

Appendix F
Daily Safety Meeting Form

Appendix G
ERM Incident Form

Figures

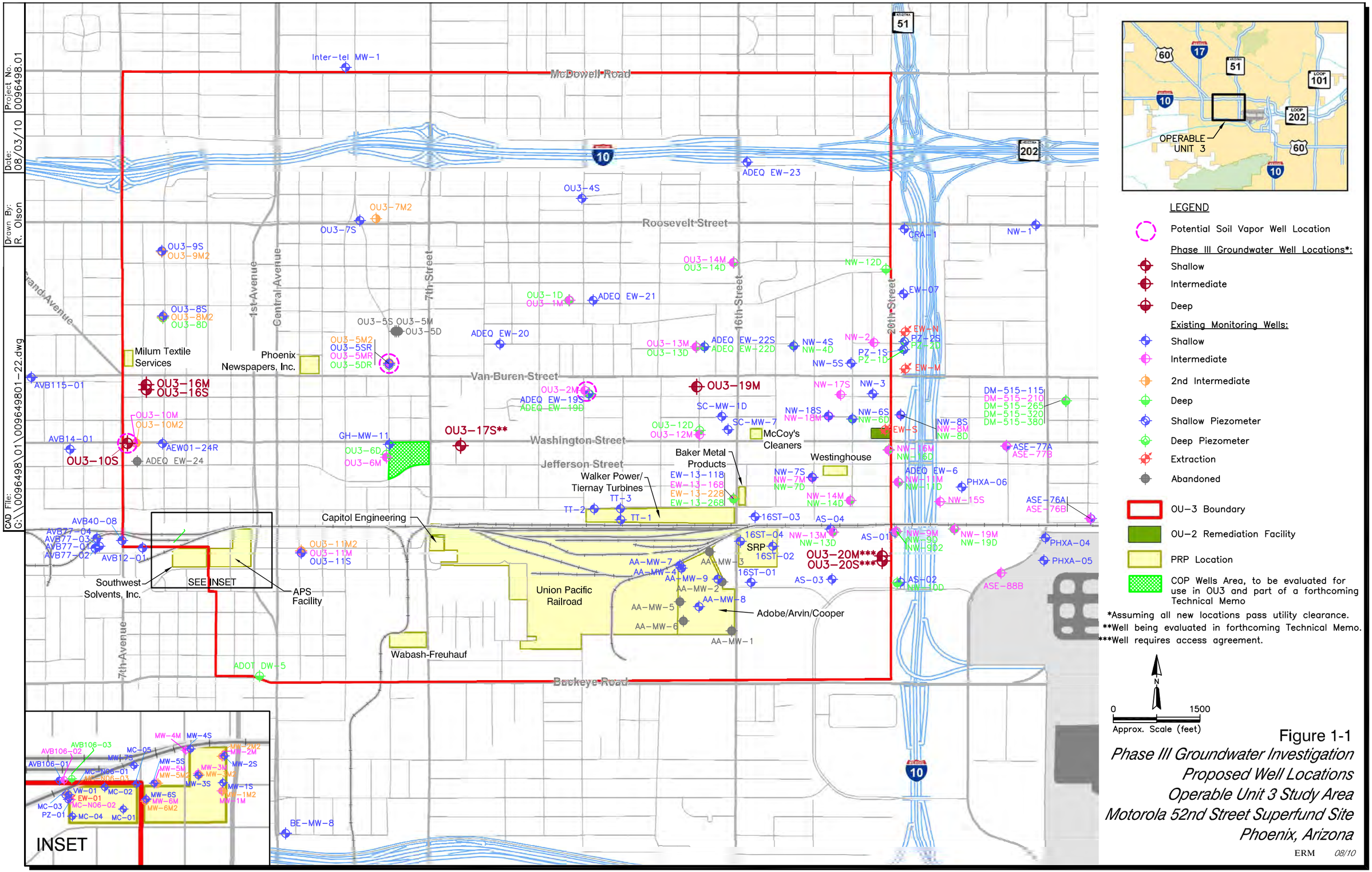
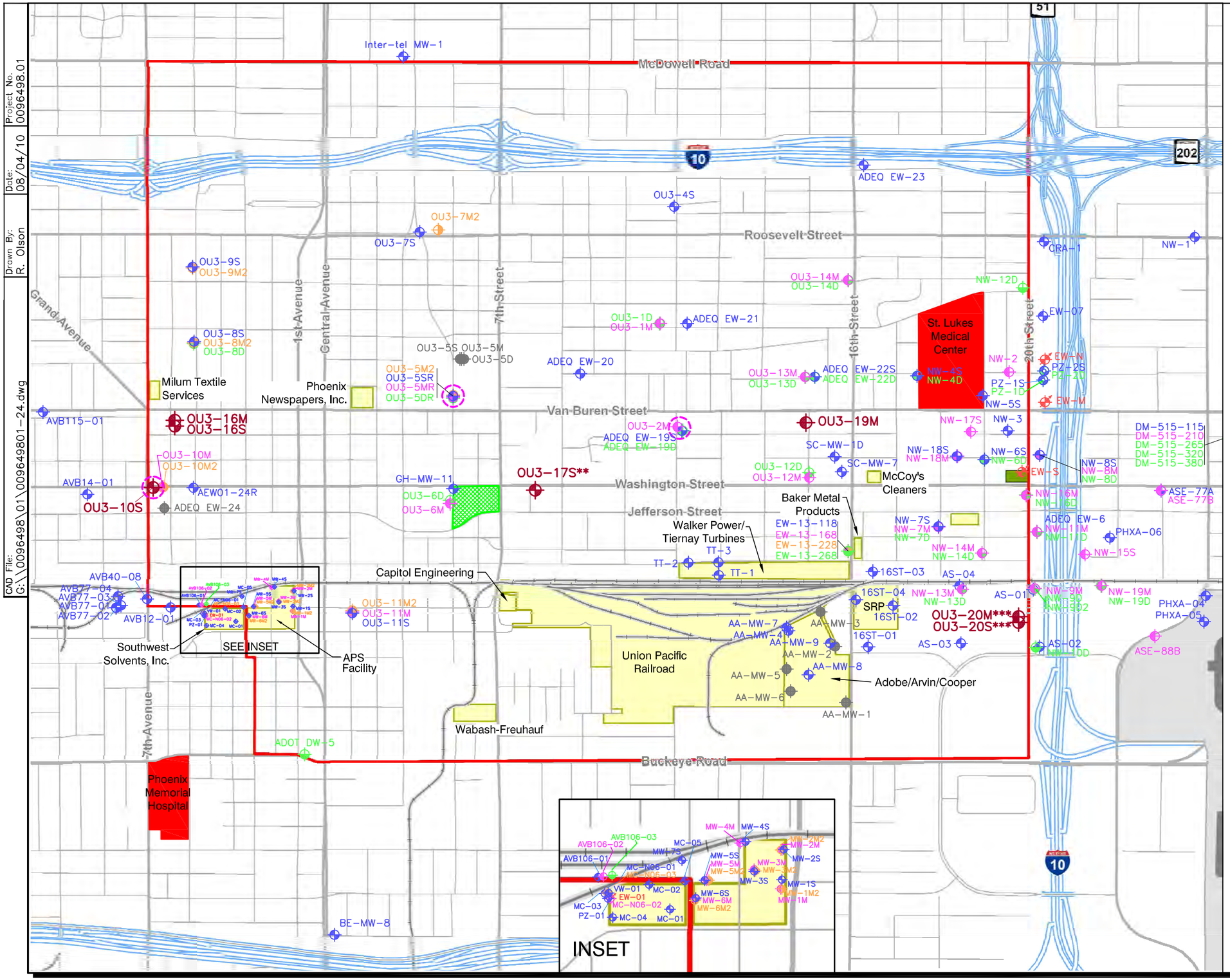


Figure 1-1

Phase III Groundwater Investigation
Proposed Well Locations
Operable Unit 3 Study Area
Motorola 52nd Street Superfund Site
Phoenix, Arizona

ERM 08/10

Appendix A
Map to Hospital



Project No. 0096498.01
Date: 08/04/10
Drawn By: R. Olson
CAD File: G:\0096498\01\0096498\01-24.dwg

Appendix A

Hospital Location Map

Operable Unit 3 Study Area

Motorola 52nd Street Superfund Site

Phoenix, Arizona

ERM 08/10

Appendix B
Task Hazard Analysis Forms

Task Hazard Analysis Worksheet

In assessing the potential hazards, determine if one task description/ analysis is sufficient. If not, then develop additional task assessments with their own steps.

Task Description (Sequence of Steps):

1. Subsurface clearance
2. Well installation (drilling)
3. Well construction
4. Soil sampling
5. Well Development
6.

Check Applicable Task Hazard	Check the Planned or Recommended Hazard Control (write in others)
☐ Asphyxiation	☐ Ventilation ☐ Supplied Air ☐ Air monitoring
× Chemical Exposure	☐ Isolation, Lockout/Tagout × PPE × Respiratory Protection ☐ Decontamination/ eyewash/ shower
× Plant, Insect, Animal Hazards	× Knowledge of particular local issues × Repellant sprays and coatings ☐ Netting, clothing covering ☐ Self-inspection schedule × First aid kit
☐ Thermal Burns ☐ Hot Surface	☐ Splash Guard ☐ Isolation, Lockout/Tagout ☐ PPE ☐ Equipment Covers ☐ Barricades
× Slips and Trips	× Ensure clean and dry surface × Barricade ×Walk Carefully/ Eyes on Path ☐ Use alternate route if wet or unstable situation ☐ Relocate the trip hazards
☐ Falls ☐ More than 4 feet	☐ Fall restraint, guardrails, barricades, short lanyard
☐ Electrical shock	☐ Isolation, LOTO ☐ Testing ☐ Grounding ☐ Shielding on equipment ☐ PPE ☐ Ground Fault Interruption on cords ☐ Electrical expertise on project team
☐ Airborne/Flying material	☐ Cover/Shield source ☐ PPE, Eye & Face ☐ PPE, Arms & Body ☐ Positioning
☐ Fire/ Explosion	☐ Isolation/LOTO ☐ Air testing/monitoring ☐ Control sources of ignition ☐ Implement a "Hot Work" process ☐ PPE ☐ The correct fire extinguisher is available
× Heat/Cold Stress	☐ Ventilation ☐ Cooling vests, etc. ☐ Task rotation, Shared tasks ☐ Work/Rest regimen ×Planned place for sheltering
× High Noise	×Hearing Protection ☐ Relocate Work ☐ Muffle Source
☐ Poor Visibility	☐ Illumination is adequate for task ☐ Nighttime considerations if the job *could* extend past daylight hours
× Lifting, pulling, pushing	☐ A plan is in place (people, devices, carts) ☐ Handling equipment is designed for the job × Proper technique known/ discussed ☐ Smaller, lighter loads?
☐ Repetitive motion	☐ Proper technique known/ discussed ☐ Proper tools, rather than manual ☐ Get help, take breaks
× Rotating equipment/ Pinch Points	☐ Isolation, LOTO × Guarding, Barricading × No loose clothing × Positioning
☐ Sharp objects	☐ Guarding ☐ Gloves, safety shoes or boots ☐ Substitute safe cutter for blade
× Falling objects	☐ Secure objects ☐ Guarding, covers × Hard Hat × Barricading
× Hazards from others working in vicinity (particularly heavy equipment)	× Communication × Barricading ☐ Shielding
× Hazards to other working in vicinity	× Communication × Barricading ☐ Shielding
× Environmental Spill	× Containment ☐ Waste Plan ☐ Waste Containers ☐ Other
☐ Chemical Storage	☐ Container labeling and MSDSs ☐ Incompatibles (acids/bases, flammables/oxidizers) considered ☐ Control physical damage to containers
☐ Drowning	☐ Personal Floatation Device ☐ Barricading ☐ Working with a partner ☐ Alerting Devices
☐ Ionizing Radiation	☐ Exposure Monitoring ☐ PPE ☐ Distance and/or shielding
× Nearby Road Traffic	× Bright colored work vests ☐ Planned avoidance of traffic areas × Signs and lights to alert drivers
× Contact with underground utilities	× Local Utility "One Call" service ☐ Access to site maps/ experience × Utility Line Locating Devices ☐ Utility Company Knowledge: × Hand Auguring before mechanical
× Hazards not listed	List Hazard Controls Follow City of Phoenix requirements for right-of-way work

	YES	NO	N/A
Is a permit (Hot Work, Confined Space Entry, Process Line Breaking, and LOTO) required for this ERM work task?		**N**	
If so is the client's procedure/policy supplied?	**X**		
Do you have the proper tools and/or equipment in good condition	**X**		
Have you planned an escape route?			**X**
Was this Hazard Analysis reviewed with the project team performing this task?	**X**		

Developed By (Individual or Team Members)
Names:_____

Date Developed:_____

Reviewed with the Following Project Employees:
_____

Task Hazard Analysis Worksheet

In assessing the potential hazards, determine if one task description/ analysis is sufficient. If not, then develop additional task assessments with their own steps.

Task Description (Sequence of Steps):

1. Groundwater Pump Test
2.
3.
4.
5.
6.

Check Applicable Task Hazard	Check the Planned or Recommended Hazard Control (write in others)
☐ Asphyxiation	☐ Ventilation ☐ Supplied Air ☐ Air monitoring
× Chemical Exposure	☐ Isolation, Lockout/Tagout × PPE ☐ Respiratory Protection ☐ Decontamination/ eyewash/ shower
× Plant, Insect, Animal Hazards	× Knowledge of particular local issues × Repellant sprays and coatings ☐ Netting, clothing covering ☐ Self-inspection schedule × First aid kit
☐ Thermal Burns ☐ Hot Surface	☐ Splash Guard ☐ Isolation, Lockout/Tagout ☐ PPE ☐ Equipment Covers ☐ Barricades
× Slips and Trips	× Ensure clean and dry surface × Barricade ×Walk Carefully/ Eyes on Path ☐ Use alternate route if wet or unstable situation ☐ Relocate the trip hazards
☐ Falls ☐ More than 4 feet	☐ Fall restraint, guardrails, barricades, short lanyard
× Electrical shock	☐ Isolation, LOTO ☐ Testing ☐ Grounding ☐ Shielding on equipment ☐ PPE × Ground Fault Interruption on cords × Electrical expertise on project team
☐ Airborne/Flying material	☐ Cover/Shield source ☐ PPE, Eye & Face ☐ PPE, Arms & Body ☐ Positioning
☐ Fire/ Explosion	☐ Isolation/LOTO ☐ Air testing/monitoring ☐ Control sources of ignition ☐ Implement a "Hot Work" process ☐ PPE ☐ The correct fire extinguisher is available
× Heat/Cold Stress	☐ Ventilation ☐ Cooling vests, etc. ☐ Task rotation, Shared tasks ☐ Work/Rest regimen ×Planned place for sheltering
× High Noise	×Hearing Protection ☐ Relocate Work ☐ Muffle Source
☐ Poor Visibility	☐ Illumination is adequate for task ☐ Nighttime considerations if the job *could* extend past daylight hours
× Lifting, pulling, pushing	☐ A plan is in place (people, devices, carts) ☐ Handling equipment is designed for the job × Proper technique known/ discussed ☐ Smaller, lighter loads?
☐ Repetitive motion	☐ Proper technique known/ discussed ☐ Proper tools, rather than manual ☐ Get help, take breaks
× Rotating equipment/ Pinch Points	☐ Isolation, LOTO × Guarding, Barricading × No loose clothing × Positioning
☐ Sharp objects	☐ Guarding ☐ Gloves, safety shoes or boots ☐ Substitute safe cutter for blade
☐ Falling objects	☐ Secure objects ☐ Guarding, covers ☐ Hard Hat ☐ Barricading
× Hazards from others working in vicinity (particularly heavy equipment)	× Communication × Barricading ☐ Shielding
× Hazards to other working in vicinity	× Communication × Barricading ☐ Shielding
× Environmental Spill	× Containment ☐ Waste Plan ☐ Waste Containers ☐ Other
☐ Chemical Storage	☐ Container labeling and MSDSs ☐ Incompatibles (acids/bases, flammables/oxidizers) considered ☐ Control physical damage to containers
☐ Drowning	☐ Personal Floatation Device ☐ Barricading ☐ Working with a partner ☐ Alerting Devices
☐ Ionizing Radiation	☐ Exposure Monitoring ☐ PPE ☐ Distance and/or shielding
× Nearby Road Traffic	× Bright colored work vests ☐ Planned avoidance of traffic areas × Signs and lights to alert drivers
× Contact with underground utilities	× Local Utility "One Call" service ☐ Access to site maps/ experience × Utility Line Locating Devices ☐ Utility Company Knowledge: × Hand Auguring before mechanical
× Hazards not listed	List Hazard Controls Follow City of Phoenix requirements for right-of-way work. Night Time work

	YES	NO	N/A
Is a permit (Hot Work, Confined Space Entry, Process Line Breaking, and LOTO) required for this ERM work task?		N	
If so is the client's procedure/policy supplied?	X		
Do you have the proper tools and/or equipment in good condition	X		
Have you planned an escape route?			X
Was this Hazard Analysis reviewed with the project team performing this task?	X		

Developed By (Individual or Team Members)
Names:_____

Date Developed:_____

Reviewed with the Following Project Employees:
_____

Task Hazard Analysis Worksheet

In assessing the potential hazards, determine if one task description/ analysis is sufficient. If not, then develop additional task assessments with their own steps.

Task Description (Sequence of Steps):

1. Groundwater purging/sampling
2.
3.
4.
5.
6.

Check Applicable Task Hazard	Check the Planned or Recommended Hazard Control (write in others)
☐ Asphyxiation	☐ Ventilation ☐ Supplied Air ☐ Air monitoring
× Chemical Exposure	☐ Isolation, Lockout/Tagout × PPE ☐ Respiratory Protection ☐ Decontamination/ eyewash/ shower
× Plant, Insect, Animal Hazards	× Knowledge of particular local issues × Repellant sprays and coatings ☐ Netting, clothing covering ☐ Self-inspection schedule × First aid kit
☐ Thermal Burns ☐ Hot Surface	☐ Splash Guard ☐ Isolation, Lockout/Tagout ☐ PPE ☐ Equipment Covers ☐ Barricades
× Slips and Trips	× Ensure clean and dry surface × Barricade ×Walk Carefully/ Eyes on Path ☐ Use alternate route if wet or unstable situation ☐ Relocate the trip hazards
☐ Falls ☐ More than 4 feet	☐ Fall restraint, guardrails, barricades, short lanyard
☐ Electrical shock	☐ Isolation, LOTO ☐ Testing ☐ Grounding ☐ Shielding on equipment ☐ PPE ☐ Ground Fault Interruption on cords ☐ Electrical expertise on project team
☐ Airborne/Flying material	☐ Cover/Shield source ☐ PPE, Eye & Face ☐ PPE, Arms & Body ☐ Positioning
☐ Fire/ Explosion	☐ Isolation/LOTO ☐ Air testing/monitoring ☐ Control sources of ignition ☐ Implement a "Hot Work" process ☐ PPE ☐ The correct fire extinguisher is available
× Heat/Cold Stress	☐ Ventilation ☐ Cooling vests, etc. ☐ Task rotation, Shared tasks ☐ Work/Rest regimen ×Planned place for sheltering
× High Noise	×Hearing Protection ☐ Relocate Work ☐ Muffle Source
☐ Poor Visibility	☐ Illumination is adequate for task ☐ Nighttime considerations if the job *could* extend past daylight hours
× Lifting, pulling, pushing	☐ A plan is in place (people, devices, carts) ☐ Handling equipment is designed for the job × Proper technique known/ discussed ☐ Smaller, lighter loads?
☐ Repetitive motion	☐ Proper technique known/ discussed ☐ Proper tools, rather than manual ☐ Get help, take breaks
× Rotating equipment/ Pinch Points	☐ Isolation, LOTO × Guarding, Barricading × No loose clothing × Positioning
☐ Sharp objects	☐ Guarding ☐ Gloves, safety shoes or boots ☐ Substitute safe cutter for blade
☐ Falling objects	☐ Secure objects ☐ Guarding, covers ☐ Hard Hat ☐ Barricading
× Hazards from others working in vicinity (particularly heavy equipment)	× Communication × Barricading ☐ Shielding
× Hazards to other working in vicinity	× Communication × Barricading ☐ Shielding
× Environmental Spill	× Containment ☐ Waste Plan ☐ Waste Containers ☐ Other
☐ Chemical Storage	☐ Container labeling and MSDSs ☐ Incompatibles (acids/bases, flammables/oxidizers) considered ☐ Control physical damage to containers
☐ Drowning	☐ Personal Floatation Device ☐ Barricading ☐ Working with a partner ☐ Alerting Devices
☐ Ionizing Radiation	☐ Exposure Monitoring ☐ PPE ☐ Distance and/or shielding
× Nearby Road Traffic	× Bright colored work vests ☐ Planned avoidance of traffic areas × Signs and lights to alert drivers
× Contact with underground utilities	× Local Utility "One Call" service ☐ Access to site maps/ experience × Utility Line Locating Devices ☐ Utility Company Knowledge: × Hand Auguring before mechanical
× Hazards not listed	List Hazard Controls Follow City of Phoenix requirements for right-of-way work

	YES	NO	N/A
Is a permit (Hot Work, Confined Space Entry, Process Line Breaking, and LOTO) required for this ERM work task?		**N**	
If so is the client's procedure/policy supplied?	**X**		
Do you have the proper tools and/or equipment in good condition	**X**		
Have you planned an escape route?			**X**
Was this Hazard Analysis reviewed with the project team performing this task?	**X**		

Developed By (Individual or Team Members)
Names:_____

Date Developed:_____

Reviewed with the Following Project Employees:
_____
_____

Task Hazard Analysis Worksheet

In assessing the potential hazards, determine if one task description/ analysis is sufficient. If not, then develop additional task assessments with their own steps.

Task Description (Sequence of Steps):

1. Vapor Sampling
2.
3.
4.
5.
6.

Check Applicable Task Hazard	Check the Planned or Recommended Hazard Control (write in others)
☐ Asphyxiation	☐ Ventilation ☐ Supplied Air ☐ Air monitoring
× Chemical Exposure	☐ Isolation, Lockout/Tagout × PPE ☐ Respiratory Protection ☐ Decontamination/ eyewash/ shower
× Plant, Insect, Animal Hazards	× Knowledge of particular local issues × Repellant sprays and coatings ☐ Netting, clothing covering ☐ Self-inspection schedule × First aid kit
☐ Thermal Burns ☐ Hot Surface	☐ Splash Guard ☐ Isolation, Lockout/Tagout ☐ PPE ☐ Equipment Covers ☐ Barricades
× Slips and Trips	× Ensure clean and dry surface × Barricade ×Walk Carefully/ Eyes on Path ☐ Use alternate route if wet or unstable situation ☐ Relocate the trip hazards
☐ Falls ☐ More than 4 feet	☐ Fall restraint, guardrails, barricades, short lanyard
× Electrical shock	☐ Isolation, LOTO ☐ Testing ☐ Grounding ☐ Shielding on equipment ☐ PPE × Ground Fault Interruption on cords × Electrical expertise on project team
☐ Airborne/Flying material	☐ Cover/Shield source ☐ PPE, Eye & Face ☐ PPE, Arms & Body ☐ Positioning
☐ Fire/ Explosion	☐ Isolation/LOTO ☐ Air testing/monitoring ☐ Control sources of ignition ☐ Implement a "Hot Work" process ☐ PPE ☐ The correct fire extinguisher is available
× Heat/Cold Stress	☐ Ventilation ☐ Cooling vests, etc. ☐ Task rotation, Shared tasks ☐ Work/Rest regimen ×Planned place for sheltering
☐ High Noise	☐Hearing Protection ☐ Relocate Work ☐ Muffle Source
☐ Poor Visibility	☐ Illumination is adequate for task ☐ Nighttime considerations if the job *could* extend past daylight hours
× Lifting, pulling, pushing	☐ A plan is in place (people, devices, carts) ☐ Handling equipment is designed for the job × Proper technique known/ discussed ☐ Smaller, lighter loads?
☐ Repetitive motion	☐ Proper technique known/ discussed ☐ Proper tools, rather than manual ☐ Get help, take breaks
☐ Rotating equipment/ Pinch Points	☐ Isolation, LOTO ☐ Guarding, Barricading ☐ No loose clothing ☐ Positioning
☐ Sharp objects	☐ Guarding ☐ Gloves, safety shoes or boots ☐ Substitute safe cutter for blade
☐ Falling objects	☐ Secure objects ☐ Guarding, covers ☐ Hard Hat ☐ Barricading
× Hazards from others working in vicinity (particularly heavy equipment)	× Communication × Barricading ☐ Shielding
× Hazards to other working in vicinity	× Communication × Barricading ☐ Shielding
☐ Environmental Spill	☐ Containment ☐ Waste Plan ☐ Waste Containers ☐ Other
☐ Chemical Storage	☐ Container labeling and MSDSs ☐ Incompatibles (acids/bases, flammables/oxidizers) considered ☐ Control physical damage to containers
☐ Drowning	☐ Personal Floatation Device ☐ Barricading ☐ Working with a partner ☐ Alerting Devices
☐ Ionizing Radiation	☐ Exposure Monitoring ☐ PPE ☐ Distance and/or shielding
× Nearby Road Traffic	× Bright colored work vests ☐ Planned avoidance of traffic areas × Signs and lights to alert drivers
× Contact with underground utilities	× Local Utility "One Call" service ☐ Access to site maps/ experience × Utility Line Locating Devices ☐ Utility Company Knowledge: × Hand Auguring before mechanical
× Hazards not listed	List Hazard Controls Follow City of Phoenix requirements for right-of-way work.

	YES	NO	N/A
Is a permit (Hot Work, Confined Space Entry, Process Line Breaking, and LOTO) required for this ERM work task?		N	
If so is the client's procedure/policy supplied?	X		
Do you have the proper tools and/or equipment in good condition	X		
Have you planned an escape route?			X
Was this Hazard Analysis reviewed with the project team performing this task?	X		

Developed By (Individual or Team Members)
Names:_____

Date Developed:_____

Reviewed with the Following Project Employees:
_____
_____

Appendix C
Toxicology Data Sheets

TOXICOLOGY PROFILES

1. TRICHLOROETHYLENE
2. PERCHLOROETHYLENE (TETRACHLOROETHYLENE)
3. BENZENE
4. VINYL CHLORIDE
5. CHLOROFORM
6. 1,1-DICHLOROETHENE

TOXICOLOGY PROFILE

Title:	**TRICHLOROETHYLENE**
Synonyms:	1,1,2-trichloroethene, 1,1,2-trichloroethylene, TCE, ethinyl trichloride, ethylene trichloride.
CAS number:	79-01-6
Boiling point:	86.7 ^{o}C
Color:	Clear, colorless, or blue mobile liquid
Conversion factor:	1 mg/m3 = 0.18 ppm (Air)
DOT designation:	Irritant
Flammable limits	
Autoignition:	none
Flash point:	none
LEL:	8.0 %
UEL:	10.5%
Henry's Law Constant:	0.020 atm-m3/mol @ 20°C
Melting point:	-73 ^{o}C
Molecular formula:	C2HCl3
Molecular weight:	131.40
Odor	
Threshold:	21 ppm (air)
Recognition:	50 ppm (air) 10 mg/L (water)
Characteristics:	Chloroform-like, sweet
Solubility	
water:	1.070 g/l water at 20 ^{o}C
	1.366 g/l water at 25 ^{o}C
Log Kow:	2.29
Log Koc:	2.42
other:	Miscible with many common organic solvents such as alcohol, ether, chloroform.
Specific gravity:	1.465 @ 20/4 ^{o}C

Vapor density: 4.53

Vapor pressure: 19.9 mm Hg at 0 °C; 57.8 mm Hg at 20 °C

Viscosity: 0.0056 poise at 25 °C

(references: Verschueren, 1983; Merck, 1989; Weast, 1987; HSDB, 1990).

COMPOSITION: Trichloroethylene is considered a volatile organic compound and a chlorinated hydrocarbon. It can be prepared by dechlorination of multichlorinated compounds for the chlorination of acetylene. It is supplied in several purity grades and may contain any number of stabilizers such as propanol, diethanolamine, aniline, morpholine, ethylene oxide, butadiene oxide, styrene oxide, thymol etc (HSDB, 1990).

USES/SOURCES: TCE is widely used as a degreaser and dry cleaning agent and an intermediate in chemical synthesis; a heat exchanging fluid and a refrigerant. It has also been used as solvent in paints, adhesives, plastics, paint removers, preparation of pharmaceuticals and cosmetics as well as a solvent for sulfur and phosphorous removal in gas purification. However, these uses are being phased out because of its potential carcinogenicity (HSDB, 1990).

ACUTE TOXICITY: The inhalation or ingestion of TCE by humans has resulted in a number of cases of sudden death due presumably to cardiac sensitization and fibrillation. Some cases of nonlethal cardiac arrest resulting from trichloroethylene exposure have also been reported. Not enough is known in these cases about the exposure conditions to establish a dose-response relationship (Kleinfeld and Tabershaw, 1954; Defalque 1961; EPA, 1985a; Wernisch et al., 1991).

The acute lethal concentration in rodents is presented in Table 1.

No toxic effects were observed by inhalation exposures to the rat (100 ppm/8hr), the rabbit (1200 ppm/473 hr) or the ape, guinea pig, rabbit and rat at 730 ppm, 8 hr/day for 6 weeks (HSDB, 1990). However, TCE is one of several volatile organic compounds that have been identified as auditory toxicants in experimental animals (Rebert et al., 1991, Jaspers et al., 1993; Crofton and Zhao, 1997). TCE produces an atypical pattern of auditory dysfunction characterized by the preferential impairment at the middle frequencies (8 and 16 kHz) of the audiogram (Pryor et al., 1987;Crofton et al., 1994; Campo et al., 1997) that can be confirmed by loss of spiral ganglion cells in the middle turn of the cochlea (Fechter et al., 1998).

Ingestion: Ingestion of TCE can cause a burning sensation in the mouth, and result in nausea, vomiting and abdominal pain (HSDB, 1990).

Cattle fed soya meal extracted with trichloroethylene developed a syndrome known variously as Stockman Disease, Duran Disease or Barbant Disease (Clarke and Clarke, 1975).

Table 1. Acute Lethal Concentration Values in Several Mammalian Species.

Species	LD50	LC50
rat	5.6 g/kg (LDlo)	26000 ppm/1 hr 12000 ppm/4 hr
mouse	2400-2450mg/kg 10 g/kg	8450 ppm/4 hr 5500 ppm/10 hr
rabbit	29 g/kg (dermal)	

(Source: HSDB, 1990)

Inhalation: Exposure to TCE vapors can irritate the mucous membranes of the nose, throat and respiratory tract. Fatal hepatic failure has been reported following the use of TCE as an anesthetic (Defalque, 1961).

Eye contact: Volunteers exposed to 27, 31 or 201 ppm trichloroethylene for four hours suffered from irritation to the mucous membranes of the eyes and throat (Nomiyama and Nomiyama, 1977). Conjunctivitis and rhinitis is associated with exposure to the fumes or vapors of TCE.

Skin contact: Contact with liquid trichlorethylene can cause intense itching, subcorneal pustular eruptions, erythema and generalized dermatitis with exfoliation (Conde-Salazar et al., 1983; Phoon et al., 1984; Bauer and Rabens, 1974, Saihan et al., 1978). Exposure to the vapors can cause skin irritation, although this effect is not common.

A condition known as Degreaser's Flush has been described in workers who drink alcohol after exposure to trichloroethylene. This syndrome is characterized by red blotches on the face neck, shoulders and backs (Stewart et al., 1974).

Dermal penetration of TCE was found to be two-fold greater in female and castrated male rats as compared to normal male rats (McCormick and Abdel-Rahman, 1991).

CHRONIC TOXICITY:

Ingestion: Stott et al. (1982) investigated the effects of orally administered trichloroethylene on rats and mice. Mice were given 2,400 mg/kg by gavage daily for 3 days, or 5 days a week. The livers of the animals from

both of these groups had altered hepatocellular morphology, centrilobular hepatocellular swelling, and necrosis. There was a statistically significantly increase in liver weight and hepatic DNA synthesis, and a slight reduction in DNA content per gram of liver. Rats treated with 1100 mg/kg trichloroethylene by gavage 5 days/week for 3 weeks had a statistically significant increase in liver weight and in hepatic DNA synthesis. Rats which received 1,100 mg/kg for three days did not have any liver changes.

Inhalation: Chronic exposures by solvent abusers can produce a loss of weight, fatigue, visual impairment, dermatitis and sometimes jaundice (HSDB,1990). Prolonged occupational exposures have been associated with a peripheral neuropathy manifested by a paralysis or loss of tactile sense in the fingers and persistent neuritis (Bardodej and Vyskocil, 1956).

Workers exposed to an average of 10 ppm TCE complained of headache, dizziness, and sleepiness. Other symptoms seen in occupational exposures include asthenia, insomnia, mood perturbations and sexual problems. One worker exposed to TCE from heated degreasing tanks, repeatedly became inebriated. He was subsequently switched to a job where he was exposed to 1,1,1-trichloroethane. He then began to suffer from fatigue, weight loss, anorexia, icterus, and abdominal swelling and diagnosed as suffering from hepatic cirrhosis (Thiele et al., 1982).

Dogs exposed to 500 - 750 ppm TCE for 4 - 8 hrs per day, 5 - 6 days per weeks developed symptoms of intoxication after 3 - 8 weeks of exposure. The symptoms included anorexia, lethargy, vomiting, loss of weight and liver dysfunction (ACGIH, 1971).

Eye contact: See ACUTE TOXICITY, Eye contact.

Skin contact: Prolonged and repeated contact with TCE can result in a defatting action and dermatitis. See ACUTE TOXICITY, Skin contact for more information.

Sensitization: No information on the sensitization potential of TCE was located.

TARGET ORGAN TOXICITY

Cardiovascular System: Trichloroethylene was extensively used as both a general anesthetic and obstetrical analgesic for a number of years. There are many reports of adverse cardiovascular effects including cardiac arrest, atrial and ventricular extrasystole, tachycardia and ventricular fibrillation (Norris and Stuart, 1957; Defalque, 1961; EPA, 1985a). TCE has been observed to cause sensitization of the cardiac muscle to epinephrine (Defalque, 1961; EPA 1985a). The same phenomena has been shown to occur in animals (White and Carlson, 1979).

A proposed mechanism for the cardiotoxic effect is free radical-induced

membrane damage. TCE in the presence of low levels of iron (Fe+3) increased lipid peroxidation two-fold in cultured arterial endothelial aortic smooth muscle cells (Tse et al., 1990).

Hepatic Effects:

Trichloroethylene is known to affect hepatic function with acute exposure. An individual who ingested an unknown amount of trichloroethylene developed jaundice and subsequently died. The autopsy revealed severe centrilobular necrosis (Kleinfeld and Tabershaw, 1954)

An occupationally exposed woman developed acute anicteric hepatitis that resolved and later developed bilateral uveitis. Upon re-exposure to TCE her serum alkaline phophatase level increased (Schattner and Malnick, 1990).

A study by Klaassen and Plaa (1966) found that the intraperitoneal ED50 for Sulfobromopthalein (SBP) retention in mice was 2,940 mg/kg. The ED50 for elevation of serum glutamyl pyruvate transferase (SGPT) was 2,352 mg/kg.

A later study found that the intraperitoneal ED50 in dogs for an increase in SGPT activity was 828 mg/kg. Moderate neutrophilic infiltration was observed at this dose but no necrosis (Klaassen and Plaa, 1967)

A number of gavage or inhalation studies with rats and mice also show hepatotoxic effects associated with TCE (HSDB, 1990).

Renal effects:

Trichloroethylene in some cases has caused adverse renal effects with chronic exposure. There is a report of tubular necrosis in two individuals who repeatedly sniffed Carbona, a solvent, with 44% trichlorethylene and 56% petroleum distillates (Baerg and Kimberg, 1970)

There are several reports of increased kidney weight in animals exposed to trichloroethylene. Male and female gerbils exposed to 150 ppm continuously for thirty days had a significant increase in kidney weight (Kjellstrand et al., 1981). NMRI mice were continuously exposed to 37, 75, 150, or 300 ppm for thirty days. The ppm males and 150 ppm males had a statistically significant increase in kidney weight (Kjellstrand et al., 1983).

ABSORPTION-METABOLISM EXCRETION:

Quantitative data on gastrointestinal absorption in humans in unavailable but case reports of accidental ingestion suggest extensive absorption (CARB, 1990).

The available animal studies indicate that rate and extent of absorption is influenced by a number of factors including the size of the dose, the vehicle, and the fasted or fed state of the animal (Parchman and Magee, 1982; Dekant et al 1984; Rouisse and Chakrabarti, 1986; Withey et al., 1983; D'Souza et al., 1985). The studies in rats indicate that absorption

is nearly complete at low doses and considerable at doses above 1000 mg/kg. Absorption is slowed by the use of a corn oil vehicle relative to water. Absorption is much faster in fasted animals.

The human blood/air partition coefficient of trichlorethylene has been estimated to range between 9.2 and 15. The TCE blood/air partition coeffecient in B6C3F1 mice is 13.4 for males and 14.3 for females (Fisher et al., 1991). Trichloroethylene diffuses easily across the alveoli and is readily soluble in the blood (Eger and Larson, 1964, Sato et al., 1977, Monster et al., 1979).

Rats were exposed to trichloroethylene for three hours at concentrations that ranged from 30 to 8000 ppm. Uptake was concentration dependent. Uptake was linear at 30 ppm but departed from linearity above 100 ppm (Andersen et al. 1980). Dallas et al. (1991) observed similar non-linear uptake in rats exposed to 50 ppm and 500 ppm for two hour intervals. Blood levels in the 500 ppm group reached concentrations 25-30 times that of the 50 ppm group during the second hour of exposure. However, the ten-fold increase in concentration inhaled resulted in only a 8.7-fold increase in total dose absorbed, indicating metabolic saturation.

Human dermal uptake has been studied by immersing the thumbs of human volunteers in liquid trichloroethylene for thirty minutes. The mean peak concentration of TCE measured in alveolar air was 0.5 ppm within thirty minutes of exposure (Stewart and Todd, 1964). The small amount of trichloroethylene found in alveolar air indicates limited absorption. A similar experiment measured blood levels and breath levels of trichloroethylene in individuals with one hand immersed in liquid trichloroethylene for thirty minutes. The highest levels of trichloroethylene were measured immediately after the end of the exposure (203.11 ug/ml in blood, 28.66 ug/ml in breath) (Sato and Nakajima, 1978). The researchers concluded that it would be unlikely harmful quantities would be absorbed dermally under ordinary workplace conditions.

Tsurata (1978) measured dermal absorption rate in mice to be in a range of 7.82 to 12.1 ug/min-cm2.

The first step in the somewhat complex process of trichloroethylene metabolism is catalyzed by cytochrome P450 mixed function oxidases where TCE is converted to trichlorethylene epoxide. This epoxide may possibly exit apart from the enzyme complex and be capable of reacting with macromolecules (Byington and Leibman, 1965; Henschler et al., 1977; Bonse et al., 1975).

Trichlorethylene oxide can then be metabolized by four different pathways. The predominant one is where trichloroethylene oxide spontaneously rearranges to form chloral hydrate. Chloral hydrate is then oxidized to trichloroacetic acid which can then be conjugated to form

trichloroacetic acid glucuronide. In the second pathway chlorohydrate is reduced to trichloroethanol most of which is conjugated to form trichloroethanol glucuronide (Costa and Ivanetich, 1984; Prout et al., 1985).

Trichloroethylene oxide can also form dichloroacetyl chloride which rearranges to dichloroacetic acid (Hathaway, 1980; Dekant et al., 1984) or oxidized and then hydrolyzed to form formic acid, glyoxylic acid, oxalic acid, carbon dioxide, and carbon monoxide (Dekant et al. 1984; Green and Prout, 1985). The isolation of N-(hydroxyacetyl)-aminoethanol indicates a fourth pathway for metabolism of trichloroethylene oxide (Dekant et al., 1984).

This difference is relevant for interspecies extrapolation. Peroxisome proliferation was not oberved in humans because metabolism of TCE to trichloracetic acid may not have exceeded the threshold necessary for proliferation. Existence of a threshold suggests mouse liver tumors may have limited relevancy in estimating human cancer risk from TCE exposure (Green, 1990).

Fisher et al., (1991) proposed that the reason that TCE induced hepatocellular carcinomas are manifested in B6C3F1 mice and not in the Fisher 344 rat is becuase the mice have a greater capacity to oxidize TCE to trichloroacetic acid.

The primary route for elimination, about 75% in the mouse, is via the urine. An additional 10% is metabolized to carbon dioxide but some of the radiolabelled TCE and its volatile metabolites were also excreted with the respiratory air. The biological half life for TCE in humans is estimated to be about 41 hours (HSDB, 1990).

GENOTOXICITY:

Most of the mutagenic data indicates trichlorethylene is only weakly mutagenic (CARB, 1990).

The Salmonella tryphimurium mutagenesis assay has been conducted on both pure and impure TCE. The most definitive assay with pure trichloroethylene is not mutagenic with or without activation (Mortelmans et al., 1986).

Reverse mutation, gene conversion, and mitotic recombination by TCE in Saccharomyces cerevisiae gave only weakly positive results (CARB, 1990).

A significant increase in DNA strand breaks was detected by the DNA unwinding assay in male mice and rats after oral doses of 1,497 and 3,009 mg/kg (Nelson and Bull, 1988). Induction of cytochrome P450 allowed the same number of strand breaks with a lower dose. Metabolites were also effective at lower doses. This is evidence that a metabolite may be responsible for causing the strand breaks.

Gu et al., (1981) found an increased incidence of sister chromatid exchanges in cultured peripheral lymphocytes from TCE exposed workers that positively correlated to the levels of trichloroacetic acid and trichloroethanol in the urine. Lymphocytes from 28 workers exposed to TCE for 1-21 years showed high rates of hypodiploid cells (Konietzko et al., 1978).

Seji et al. (1990) observed an increased frequency of sister chromatid exchanges in cultured peripheral lymphocytes from male workers exposed to TCE and who smoked as compared to concurrent non-smoking controls, indicating possible synergism between exposure and smoking.

NEUROTOXICITY:

There are central nervous system effects which result from chronic or acute exposure to TCE. Occupational exposure has caused nausea, headache, loss of appetite, weakness, dizziness, ataxia and tremors (Mitchell and Parsons-Smith, 1969; Okawa and Bodner, 1973).

Trichlorethylene is a potent central nervous system depressant whose properties led to its use as an anesthetic (Striker et al., 1935). High concentrations of trichloroethylene have been reported to cause cranial nerve damage that has produced esophageal motility impairment, deafness or other irreversible nerve damage (Mitchell and Parsons-Smith, 1969; Buxton and Hayward, 1967; Barret et al., 1982). There are reports of trigeminal nerve impairment in chronically exposed workers (Barret et al, 1982) and a case history of reversible auditory nerve damage but information on the duration and level of exposure are not available. However, occupational exposure to TCE at approximately 22 ppm appeared not to impair sympathetic nerve activity (Nagaya et al. 1990). Impaired performance on psychophysiological tests has also been reported following exposure to TCE at levels of 500 and 1000 ppm (Vernon and Ferguson, 1969; Stopps and McLaughlin, 1967).

REPRODUCTIVE TOXICITY:

As part of an larger epidemiological study, the effect of maternal trichloroethylene exposure on congenital malformations was investigated (Tola et al., 1980). No malformed babies were born during the thirteen years of the study although three would have been expected.

A variety of animal reproductive studies have been carried out with mostly negative results. Zenick et al. (1984) investigated the effects of TCE exposure on the reproductive function of male rats at a dose level of 1000 mg/kg/day. No significant observational effects or behavioral patterns were found.

Dawson et al. (1990), observed a dose-dependent increase in congential heart abnormalities in rats exposed <u>in utero</u> to TCE during organogenesis.

Manson et al., 1984 investigated the effect of TCE on the reproductive

performance of female rats. The rats were treated with up to 1000 mg/kg of TCE daily for 6 weeks through day 21 of gestation. The litters from the high dose females had a statistically significantly increased incidence of fetal death.

Schwetz et al. (1975) exposed mice and rats to 300 ppm of trichloroethylene 7 hours/day on days 6 through 15 of gestation. The treatment had no effect on any of the embryological or reproductive indices examined.

Healy et al., (1982) exposed rats to 100 ppm TCE for 4 hours/day during days 8 to 21 gestation and found a statistically significant delay in fetal weight gain and increased incidence of fetal resorptions.

Bross et al. (1983) injected TCE into fertilized chick eggs. More than 75% of the treated embryos had malformations which consisted of a significant difference in the crown-rump length, beak length, wing length, and toe length.

Although TCE appears to be somewhat fetotoxic in rodents. It does not appear to have other adverse reproductive effects (EPA, 1985a).

CARCINOGENICITY:

Trichloroethylene has been found to be carcinogenic in several animal studies. The National Cancer Institute (NCI,1976) conducted a gavage cancer bioassay in B6C3F1 mice and Osborne-Mendel rats. Industrial grade TCE was used which contained 0.09% epichlorohydrin as a stabilizer. A large increase in hepatocellular carcinoma was seen in the mice but not the rats. This study has been criticized because of the high TCE doses and early mortality. In addition the question of purity of the TCE has been raised but an analysis of the number of cancers due to the epichlorohydrin could not account for the increased incidence of hepatocellular carcinoma (CARB, 1990).

The National Toxicology Program (NTP, 1983) repeated the study but with TCE stabilized with diisopropylamine. The mice were dosed by gavage with 1000 mg/kg, 5 days a week for 103 weeks. The F334/N rats were dosed with 500 or 1000 mg/kg on the same schedule. The exposed mice showed a significantly higher incidence of hepatocellular carcinoma thus confirming the earlier NCI (1976) study. In addition, the high dose male rats experienced a highly statistically significant increase in the incidence of renal tubular-cell adenocarcinoma.

Other studies have found an increase in pulmonary tumors in mice which were not dose dependent (Maltoni et al., 1986) (Fukuda et al., 1983).

Paraf et al. (1990) reported a squamous cell carcinoma of the gall bladder with hepatic metasteses in an individual occupationally exposed to TCE.

EPIDEMIOLOGY: A number of retrospective and prospective epidemiological studies have been conducted to determine if occupational exposure to trichloroethylene causes an increased incidence of cancer. These studies have been inconclusive (CARB, 1990). A mortality study of 2117 workers exposed to TCE failed to show a correlation with liver cancer (Tola et al., 1980)

Nakajima et al. (1990) observed a correlation between occupational TCE exposure and primary pneumatosis cystoides intestinalis; a non carcinogenic effect.

ENVIRONMENTAL FATE: **Air-** Most of the trichloroethylene which is used in the United States is released into the atmosphere due to its volatility. Foods open to the air may become contaminated by the uptake of TCE (Grab et al., 1991).

The dominant reaction for trichloroethylene removal from air is its reaction with hydroxyl radicals. This reaction has an estimated half life of approximately 6.8 days (EPA, 1985a). The breakdown products include phosgene, dichloroacetyl chloride, and formyl chloride (Atkinson and Carter, 1984). The relatively short half life of trichloroethylene should not allow long-range global transport of significant levels (Class and Ballschmiter, 1986).

Water- Trichloroethylene has been shown to volatilize rapidly to form water in laboratory studies (Smith et al. 1980; Roberts and Danliker, 1983; Okouchi, 1986; Dilling, 1977; Dilling et al. 1975). Volatilization is dependent upon the temperature, water movement, water depth, associated air movement and other factors, but, McKone and Knezovich (1991) determined that 61±9% TCE in shower water volatized independent of temperature between 37-22oC. The estimated volatilization half lives from typical bodies of water are: 11 days for a pond, 4 to 12 days for a lake, 1 to 12 days for a river (EPA, 1985b).

In groundwater where volatilization cannot occur, biodegradation may be the most important process for removal. Slow biodegradation of trichloroethylene does occur under anaerobic conditions (Barrio-Lage et al. 1987; Fogel et al. 1986).

Soil- Experimentally determined soil sorption coefficients (Koc) for trichlorethylene range from 41 to 42 (Garbarini and Lion, 1986; Skaane et al., 1986; Stauffer and MacIntyre, 1986). The soil adsorption coeffecient for TCE in silty clay was estimated to be 11.7 mL/g. In a short soil column TCE showed an initial rapid desorption rate and followed by a slower rate. Batch desorption reached steady-state in 24 hours (Pavlostathis and Jaglal, 1991). Koc's of this magnitude indicate a high soil mobility. Groundwater monitoring studies have detected trichloroethylene in groundwater which is further evidence for its high mobility (ATSDR, 1989).

Animals-An experimentally measured bioconcentration factor of 17 has

been reported for trichloroethylene (Veith et al. 1980; Barrows et al., 1980). A low bioaccumulation potential has also been reported for fish (Kawasaki, 1980).

Humans-Eight out of eight samples of breast milk from women living in urban area tested positive for trichloroethylene (Pellizzari, 1982). Post-mortem wet tissue samples have been reported to contain 1-32 ppb trichloroethylene (IARC, 1976)

ENVIRONMENTAL TOXICITY:

Acute ecotoxicity values for several species are presented in Table 2.

REGULATORY STATUS: **Carcinogenicity**: IARC (1987) has determined that there is limited evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans. Therefore, TCE cannot be classified as to its carcinogenicity to humans. The EPA (1985a) concluded that evidence for carcinogenicity of trichloroethylene in animals was sufficient but epidemiological data were inconclusive and classified TCE as Group B2, a probable human carcinogen.

Risk Assessment- CARB, (1990) has determined the unit risk from breathing 1 ug/m3 trichloroethylene for a lifetime to be 8 X 10-7 to 9 X 10-6. This is based on combining the values from the metabolized and applied dose approaches.

The NRC has calculated a unit risk for 1 ug TCE/L at 3.77 x 10 -7 for males and 6.84 x 10-8 for females (NRC, 1983).

Drinking water: A Maximum Concentration Limit Goal (MCLG) of 0 mg/L has been proposed by the EPA based on the carcinogenicity of trichloroethylene. The proposed MCL is 5 ug/L (IRIS, 1990) which is at the detection limit of the analytical methodology.

Trichloroethylene has been listed as a carcinogenic chemical under the California Proposition 65 regulation.

Table 2. Acute Ecotoxicity Values in Several Species.

Species	Values	Test
Entosiphon sulcatum (protozoa)	1200 mg/L	Cell Multiplication Inhibition
Uronema parduczi (protozoa)	> 960 mg/L	Cell Division Inhib.
Scenedesmus quadricauda (green algae)	> 1000 mg/L	Cell Division Inhib.
Microcystis aeruginnosa (algae)	63 mg/L	Cell Division Inhib.
Grass shrimp	LC50 = 2 mg/L	96 hr assay
Mexican Axolot	LC50 = 48 mg/L	48 hr assay
Pimephales promelas (fathead minnow)	LC50 = 40.7 mg/L	96 hr flow thru assay
Pimephales promelas (fathead minnow)	LC50 = 66.8 mg/L	96 hr static assay
Sheepshead minnow	LC50 = 20 mg/L	96 hr assay
Bluegill sunfish	LC50 = 44.7 mg/L	96 hr static assay
clawed toad	LC50 = 45mg/L	48 hr assay

(Source: HSDB, 1990)

Worker exposure limit values are presented in Table 3.

Table 3. Worker Exposure Limit Values.

STANDARD	VALUE
ACGIH TLV	50 ppm
STEL:	100 ppm
OSHA TWA:	100 ppm

(Source: ACGIH, 1994; NIOSH, 1994).

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TOXICOLOGY PROFILE

PERCHLOROETHYLENE

Synonyms:	1,1,2,2-Tetrachloroethylene, tetrachloroethene
CAS number:	127-18-4
Boiling Point:	250 °F
Color:	Colorless
Conversion Factor:	1 ppm = 6.89 mg/m^3
Flammability:	none
Freezing Point:	-2°F
Molecular formula:	C_2Cl_4
Molecular weight:	165.83
Odor:	
Threshold:	27 ppm
Recognition:	50 ppm
Characteristics:	Mildly sweet, chloroform-like odor (U. S Coast Guard, 1984)
Specific Gravity:	1.62 (water = 1)
Solubility:	
Water:	0.15 gm/100 ml at 25 °C
Kow:	2.51 x 10^3
Vapor density:	5.7 (air = 1)
Vapor pressure:	18.4 mm Hg at 25 °C (Riddick et al., 1986)
Viscosity:	0.839 at 25 °C

Ref: IARC, 1979; Riddick et al., 1986; Clayton and Clayton, 1981; HSDB, 1991)

USES

Perchloroethylene is used as a dry cleaning agent, in the textile industry for processing and finishing, as a chemical intermediate in the synthesis of fluorocarbons 113, 114, 115, and 116, as a heat exchange fluid and in transformers as an insulating fluid and cooling gas (IARC, 1979). Perchloroethylene is also widely used as a solvent. It is utilized as metal

decreasing agent both in cold cleaning and vapor decreasing, in a typewriter correction fluids and as a ruminant and small animal anthelmintic but this use has been largely replaced by less toxic more easily administered drugs (Toxnet, 1990). (Toxnet, 1990).

ACUTE TOXICITY

Perchloroethylene like other chlorinated hydrocarbons causes central nervous system depression. In human studies it has been determined that 100 ppm is around the No Observed Adverse Effect Level. Lightheadness begins around 200 ppm. Exposure to 1500 ppm causes complete incoordination and loss of consciousness after about 30 minutes (Hake and Stewart, 1977).

The acute lethal oral dose in the rat is reported to be greater than 5000 mg/kg. The acute oral LD_{50} in the mouse is reported to be in the range of 8000 - 11,000 mg/kg (Verscheuren, 1983).

Ingestion:

The absorption of perchloroethylene has been indirectly measured by determining the percentage of the dose recovered following oral administration of perchloroethylene in mice and rats. The amount varied between 80 and 100% (Pegg et al., 1979).

Inhalation:

Inhaled perchloroethylene is readily absorbed due to the lipophilic nature of the compound. The human blood/ gas coefficient has been estimated by different investigators to 10.3 and 16 (Monster et al., 1979)(Gargas et al., 1986).

Monster et al., 1979 estimated that 62 to 64% of an inhaled dose of a 72 or 144 ppm administered to human volunteers over 4 hours was absorbed. In mice exposed to approximately 2,000 ppm, absorption varied from 42 to 87% (Yilner, 1961).

Rats exposed to perchloroethylene at 1000 ppm and 2000 ppm for four hours demonstrated increased blood levels of the liver enzymes SGOT, SGPT, glucose 6-phosphatase, and ornithine carbamyl transferase (Drew et al., 1978).

Eye Contact:

Perchloroethylene caused abrasion of the epithelium and conjunctivitis when applied to the eyes of rabbits. (Duprat et al., 1976). Perchloroethylene in the vapor form causes eye irritation starting at the 200 ppm level (Hake and Stewart, 1977).

Skin contact:

There is a report of a worker suffering erythema and superficial burns following the spilling of liquid perchloroethylene on the skin (Reynolds and Prasad, 1982).

Perchloroethylene is reported to be extremely irritating when applied topically to the skin of rabbits (Duprat et al., 1976). In another investigation perchloroethylene caused no visible sign of skin irritation when dermally applied to guinea pigs (Jakobsen et al., 1982).

Dermal absorption of tetrachloroethylene vapor (600 ppm) in humans was investigated by exposing human volunteers with full face mask respirators to prevent inhalation exposure. An insignificant amount was absorbed which was comparable to about 1% of the dose which would have been absorbed by inhalation of 600 ppm (Riihimaki and Pfaffli, 1978).

Dermal absorption of perchloroethylene liquid was investigated by immersing one thumb of human volunteers in liquid perchloroethylene. The concentration of perchloroethylene in exhaled air was then measured. A peak concentration of 0.31 ppm in exhaled air was measured after 40 minutes, an indication of slow human dermal absorption (Steward and Dodd, 1964). The rate of absorption of liquid perchloroethylene through mouse skin has been determined to be 0.24 mg/hour-cm^2 of skin (Tsuruta, 1975).

CHRONIC TOXICITY

NEPHROTOXICITY:

Rats were exposed to perchloroethylene at 0,70, 230 or 470 ppm for 8 h/day, 5 days/week for 7 months. No pathological renal changes were seen at the 70 ppm level. At the 230 ppm level renal congestion was observed 20 days after termination of exposure. In the 470 ppm group increased renal secretion with cloudy swelling and desquamation in the kidneys was observed 46 days after termination of exposure (Carpenter, 1937). In contrast to these results no abnormal renal function or histopathological findings were observed in rats, rabbits, guinea pigs, or monkeys exposed to tetrachloroethylene vapor at concentrations of 0, 100, 200, or 400 ppm for 7 hours per day, 5 days per week for 6 months (Rowe et al., 1952).

In the NTP (1986) study F344/N rats were exposed to 0,200 or 400 ppm tetrachloroethylene for 6 hours per day 5 days per week for 103 weeks. B6C3F1 mice were exposed to 0, 100, or 200 ppm with the same schedule. In both species a dose related incidence of renal tubular cell karyomegaly was observed. A low incidence of renal tubular cell hyperplasia was observed in male rats accompanying the renal tubular cell karyomegaly.

No clear causal relationship has been established between human exposure to perchloroethylene and renal damage (ATSDR, 1987).

HEPATOTOXICITY:

There are a number of case studies of accidental exposures which report liver damage following acute or chronic inhalation of perchloroethylene. The hepatoxic effects include cirrhosis of the liver, toxic hepatitis, liver cell necrosis, hepatomegaly, and increased levels of serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvate transaminase (SGPT), lactic dehydrogenase (LDH), bilirubin, and Alkaline phosphatase (Hake and Stewart, 1977).

In the NTP (1986) carcinogenicity assay, the B6C3F1 mice were exposed to 0, 100, 200 ppm for 6 hours per day, 5 days per week for 103 weeks. At the 200 ppm concentration liver degeneration and necrosis occurred. The rats in this study exposed to 0, 200, 400 ppm under the same schedule did not show hepatic effects.

ABSORPTION, METABOLISM AND EXCRETION

Metabolism of perchloroethylene is known to involve cytochrome P-450 mixed function oxidases (Bonse et al., 1975)(Greim et al., 1975). Perchloroethylene metabolism in rats is increased five to seven times by prior treatment with the mixed function oxidase inducers phenobarbital and Aroclor 1254 (Moslen et al., 1977). The first step is thought to involve the cytochrome P-450 catalyzed formation of a reactive intermediate tetrachloroethylene oxide (Bonse et al., 1975)(Greim et al., 1975). Tetrachloroethylene oxide is hypothesized to undergo a spontaneous rearrangement to trichloroacetyl chloride and subsequent hydrolysis to trichloroacetic acid.

A second pathway which has been identified in rodents is thought to involved the formation of chloroethylene glycol by rearrangement of trichloroethylene oxide catalyzed by epoxide hydrolase (Pegg et al., 1979). Chloroethylene glycol may then undergo hydrolysis to oxalic acid, or formic acid and carbon dioxide. It has not been determined if this pathway is operative in man.

The trichloroacetyl chloride, trichloroacetic acid, oxalic acid, and carbon dioxide have all been isolated as products of metabolism in vivo in various species. The other intermediates are hypothesized to exist. In rodents trichloroethanol, dichloroacetic, ethylene glycol and a thioether have been identified as urinary metabolites. In humans trichloroacetic acid and trichloroethanol have been identified as the major metabolites. The identification of other metabolites has been hindered by the lack of a study in which radiolabelled perchloroethylene has been used as tracer.

The amount of perchloroethylene metabolized is species dependent. It has been estimated that only 1 to 2 % of the absorbed inhaled dose in humans exposed for four hours to 72 or 144 ppm of perchloroethylene (Monster et al., 1979). The trichloroethanol and trichloroacetic acid are excreted as urinary metabolites. Limited information suggests that human metabolism is saturable at approximately 400 ppm (Ohtsuki et al., 1983). Data is available for both rats and mice indicating saturable metabolism in these species (Mitoma et al., 1985)(Buben and O'Flaherty, 1985). Pulmonary elimination of unmetabolized perchloroethylene has been reported to be triphasic with half lives 12 to 16 hours, 30 to 40 hours, and 50 to 55 hours respectively (Monster et al., 1979).

REPRODUCTIVE TOXICITY: In one investigation male guinea pigs exposed to 1600 ppm 7 hours a day for 8 exposures within ten days showed slight microscopic degenerative changes in the germinal epithelium of the testes (Rowe et al.,

1952). This finding has not been confirmed by subsequent studies.

GENOTOXICITY:

Both pure and technical grade perchloroethylene have been tested in the Salmonella tryphimurium system (Ames test) with various strains both with and without metabolic activation several times. Cerna and Kypenova (1977) tested perchloroethylene of unspecified purity and found a dose-dependent statistically significant increase in the number of revertants in strain TA 100 which is sensitive to base pair substitutions. They tested concentrations of 0.01, 0.1, and 1.0 mg/ml. Other investigators have reported negative results in the Ames test with and without metabolic activation (Kringstad et al., 1981)(NTP, 1986)(Bartsch et al., 1979).

Perchloroethylene was negative in the Drosophila lethal mutation test (NTP, 1986). Results were also negative with and without metabolic activation with the L5178Y/TK$^{+/-}$ mouse lymphoma cell mutagenesis test system (NTP, 1986). In conclusion it is unlikely that perchloroethylene is mutagenic by the criteria of in vitro testing.

CARCINOGENICITY:

A number of animal studies have investigated the carcinogenicity of perchloroethylene. The National Cancer Institute conducted a study in which B6C3F1 mice and Osborne Mendel rats were dosed with perchloroethylene by gavage, 5 days/week for 78 weeks (NCI, 1977). The rats and mice were then sacrificed after an additional 32 weeks and 12 weeks respectively. The average daily doses of perchloroethylene were 536 and 1072 for the male mice, 386 and 722 mg/kg for female mice, 471 and 941 mg/kg for male rats, and 474 and 949 mg/kg for female rats. Perchloroethylene caused a statistically significant increase in the incidence of hepatocellular carcinoma in the male and female mice at both the high and low doses. However, the high doses used caused very high early mortality in both the rats and mice. The methodological problem has cast doubt on the findings of this study.

The National Toxicology Program (1986) conducted the best carcinogenicity study available. In this study B6C3F1 mice and F-344 rats were exposed to 99.9% pure perchloroethylene by inhalation for 6 hours a day, 5 days a week for 103 weeks. The mice and rats were exposed to 0, 100, 200 ppm, and 0, 200, 400 ppm respectively. The incidence of mononuclear cell leukemia was significantly increased in both high and low dose male and female rats. The high and low dose male and female mice had a large statistically significant increase in the incidence of hepatocellular carcinoma.

IARC (1987) concluded largely on the basis of the NTP (1986) study that there was sufficient evidence of carcinogenicity in animals (group 2B) but the evidence in humans was inadequate.

EPIDEMIOLOGY:

Several epidemiological studies of dry cleaner workers have been conducted. These studies are largely retrospective and too small to have much power. The studies are also confounded by possible worker

exposure to the stoddard solvents, and other chlorinated hydrocarbons used as dry cleaner solvents prior to 1960 (CARB, 1989).

ENVIRONMENTAL FATE: **Air** - Because of its volatility, air is major means of perchloroethylene distribution. Perchloroethylene is removed from the atmosphere by reaction with hydroxyl radicals. Reactions with nitrate radicals, ozone and physical removal processes are thought to be have too long a half life to be of significance (CARB, 1989). Based on the predominant reaction with hydroxyl radical the half-life in the atmosphere is estimated to be 68 days (Cupitt, 1983). Products of perchloroethylene oxidation in chamber studies have been found include hydrogen chloride, phosgene and trichloroacetyl chloride (Gay, 1976). Trichloroacetyl chloride can break down further to form carbon tetrachloride (Singh, 1977).

Water: In laboratory studies perchloroethylene has been shown to volatilize rapidity from water (Smith et al. 1980)(Okouchi, 1986). Volatilization half lives have been estimated to be 7 days for ponds, 1.4 days for rivers, and 5.6 days for lakes (ATSDR, 1987). Volatilization is by far the most important removal process for water with access to the atmosphere.

Perchloroethylene is slowly transformed in water by hydrolysis and perhaps in part by biodegradation. The estimated half life of the perchloroethylene hydrolysis reaction in water at 25 °C is 9 months (Dilling et al., 1975). Perchloroethylene is biodegraded slowly if at all (Bouwer et al, 1981, Bouwer and McCarty 1982, Mudder and Musterman 1982, Sasaki 1978, Wakeham et al. 1983, Wilson et al. 1983). Perchloroethylene is persistent in contaminated ground water due to the absence of the volatilization pathway of removal.

Soil: Experimentally determined soil sorption coefficients (Koc) for perchloroethylene range from 137 to 363 (Chiou et al., 1979. Friesel et al., 1984. Kenaga 1980, Schwarzenbach and Westall 1981, Seip et al. 1986). This indicates that perchloroethylene would have medium to high soil mobility. A number of monitoring studies have found perchloroethylene in ground water providing further evidence of mobility. The Koc data indicates that tetrachloroethylene will not partition significantly from water into sediments.

Perchloroethylene's low absorption to soil and volatility mean that evaporation into air where possible is an important route of removal from the soil. Perchloroethylene which is not volatilized will tend to reach ground water because of the lack of absorption to soil.

ENVIRONMENTAL TOXICITY:

Plants: In samples of wheat tested for perchloroethylene 20 % were positive with values ranging from 1.8 to 2.1 ppb. Two samples of corn were positive with values of 0.45 and 0.54 ppb (Heikes and Hopper, 1986).

Animals: Bioconcentration factors measured experimentally for tetrachloroethylene in fish have been found to range from 39 to 49 Barrows et al. 1980), Neely et al. 1974, Veith et al. 1980, Kenaga 1998). The bioconcentration factors indicate that little bioconcentration should occur. Measured values in fish from various sources have ranged from the low parts to billion to nearly two hundred parts per billion (toxnet, 1990).

Perchloroethylene has been detected at 0.9 to 1 ug/kg in samples of English beef (McConnel et al., 1975) Another study did not detect perchloroethylene in various meats (detection limit 4.6 ppb) (Entz and Hollifield, 1982)

Humans: A survey of the blood levels of perchloroethylene of 121 males and 120 males in the United States revealed that blood levels ranged from 0.4-23 ppb with an average of 2.4 ppb (Antoine et al., 1986). When perchloroethylene levels were measured in 62 composite human adipose tissue samples, 61 % were found to be positive (detection level 3 ppb). The highest level measured 94 ppb (Stanley, 1986)

REGULATORY STATUS: The California Department of Health Services has estimated the unit risk for lifetime exposure to 1 ug/m^3 air to be between 5 and 21 X 10^{-6}. This represents the upper 95% confidence interval range of risks (CARB, 1989). This estimate is based on a delivered dose model. The EPA estimates that range of unit risk for lifetime exposure to 1 ug/m^3 is from 2.9 X 10^{-7} to 1.1 X 10^{-5}. This range of risk incorporates a metabolized dose model as well as a delivered dose model (USEPA, 1986).

Worker Exposure limits are presented in the following table.

ACGIH	
TLV	25 ppm (170 mg/m^3)
STEL	100 ppm (685 mg/m^3)
OSHA	
TWA	100 ppm (684 mg/m^3)
IDLH	500 ppm

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TOXICOLOGY PROFILE

Title:	**BENZENE**
Synonyms:	Benzol, Cyclohexatriene, Coal naphtha, Cyclohexatriene, Phenyl hydride, Polystream, Pyrobenzol
CAS No:	71-43-2
Boiling point:	80.1 °C
Color:	Clear, colorless liquid, Rhombic crystals
Conversion Factors:	1 ppm = 3.242 mg/m^3 Blood/air partition coefficient = 7.8
DOT Designation:	highly flammable liquid
Evaporation half life: (from water):	2.7 - 3.5 hrs.
Evaporation rate:	2.8 (ether = 1)
Flammable limits:	
autoignition:	1044 °F
flash point:	-11 °C (12 °F)
LEL:	1.3%
UEL:	7.1%
burning rate:	6.0 mm/min
Henry's Law Constant:	5.59 x 10^{-3}atm-m^3/mole @ 20°C
Melting point:	5.5 °C
Molecular formula:	C_6H_6
Molecular weight:	78.11
Odor:	
Threshold:	4 - 5 ppm
Recognition:	34-119 ppm
Characteristics:	strong aromatic

Solubility:

Water:	820 mg/l @ 22°C, 1000 mg/l @ 25°C
Kow :	1.56 - 2.15
Other:	Miscible in non aqueous solvents
Koc :	0.3 - 100
Specific gravity:	0.875 g/cm^3 @ 20 °C
Vapor density:	2.7 (air=1)
Vapor pressure:	60 mm Hg @ 15 °C 76 mm Hg @ 20 °C 100 mm Hg @ 26°C
Viscosity:	0.654 centipoise at 20°C.

(Source: HSDB, 1990; Merck 1989; ATSDR, 1989)

USES:

Benzene is used primarily as a solvent, degreaser, fuel additive, and starting material for pharmaceutical and synthetic chemicals. It is used in the manufacture of a wide variety of consumer goods including plastic containers, radios, toys, sporting goods, furniture, appliances, automobiles, tires, lubricants, dyes, drugs and agricultural chemicals. Benzene also occurs in gasoline at concentrations between 1% to 5%. Most of the produced benzene remains in petroleum fuels such as gasoline (ATSDR, 1987).

The use of benzene in industrial processes and by consumers has been decreasing. In the past, benzene was used as a solvent in paints and paint strippers, arts and crafts supplies, rubber cement in tire patch kits, carburetor cleaners and denatured alcohol. Other solvents have now replaced benzene in these uses (ATSDR, 1987).

ACUTE TOXICITY:

The characteristic pattern of acute benzene intoxication is central nervous system stimulation followed by respiratory depression, loss of consciousness and death (Goldstein, 1977). The onset and progression of these signs and symptoms is dose dependent.

The LD_{50s} for various species, as reported in RTECS (1990), are are provided in Table 1.

Ingestion:

Acute LD_{50} values for oral exposure to benzene in rats are age-dependant, and range from 0.87 g/kg to 5.6 g/kg (Kimura, et al., 1970). Benzene can be readily absorbed from the gastrointestinal tract following oral dosing. Following the oral administration of ^{14}C labelled benzene to rabbits, approximately 90% of the administered dose was recovered in the exhaled air and urine (Parke and Williams, 1953).

Table 1.
Acute Toxicity Values for Benzene in Laboratory Animals

Species	Route of Administration	Type	Test Concentration
Rat	Oral	LD_{50}	3306 mg/kg
Rat	Intraperitoneal	LD_{50}	2890 □g/kg
Mouse	Oral	LD_{50}	4700 mg/kg
Mouse	Intraperitoneal	LD_{50}	340 mg/kg

In humans, case studies of accidental or intentional ingestion also indicate that benzene is readily absorbed. The signs and symptoms following benzene ingestion include: a burning sensation of the mouth and esophagus, nausea, vomiting, dizziness, staggering gait, somnolence, loss of consciousness, and delirium. Other CNS effects include visual disturbances and convulsions, feelings of excitement and euphoria with sudden onset of weariness, fatigue and sleepiness followed by coma. Due to the volatility of benzene, there is also the danger of aspiration into the lungs during vomiting resulting in a chemical pneumonitis. Chemical pneumonitis is characterized by choking, shortness of breath, sensation of constriction in the chest and fever (Sandmeyer, 1981). Cardiovascular effects include shallow rapid pulse and pallor, followed by flushing. Progressive CNS depression, respiratory insufficiency, and ventricular fibrillation may result in death. The estimated fatal oral dose for humans has been reported to range between 9 - 30 grams or 129 mg/kg to 429 mg/kg (Sandmeyer, 1981).

Inhalation:

Dogs and mice exposed to 600 to 1000 ppm (2,089 - 3,482 mg/m^3) of benzene via inhalation for 12 to 15 days developed leukopenia and fatal anemia, respectively (Hough and Freeman, 1944; Petrini, 1941). Rats, guinea pigs, rabbits, and monkeys also developed leukopenia when dosed via inhalation at 80 to 85 ppm (279 - 295 mg/m^3) for 136 to 187 times (Wolf et al., 1956).

Winek and Collum (1971) reported three fatal cases associated with "sniffing" episodes. One boy died as a result of sniffing rubber cement; another boy died after sniffing benzene. The last victim accidentally shot himself while in a euphoric state after sniffing glue. Blood and tissue analysis ranged as follows: blood - 0.094 - 6.5 mg%; fat - 2.23 mg%; brain - 3.9 mg%; kidney-0.55 - 1.9 mg%. At autopsy, inflammation of the respiratory tract, hemorrhages in the lungs, congestion in the kidneys, and cerebral edema were seen. Notably, there were no hematological effects. Sandmeyer (1981) estimated that exposure to 19,000 - 20,000 ppm for 5 to 10 minutes may prove fatal and the toxicity is most likely attributable to benzene directly rather than any of its metabolites.

Skin contact:

Benzene was reported to be moderately irritating to the skin of rabbits. Repeated exposures (20 applications) produced erythema, edema, exfoliation, blistering, and moderate necrosis (Wolf et al., 1956).

Eye contact: Direct contact with undiluted benzene produces moderate eye irritation with slight transient corneal injury. Small areas of superficial corneal necrosis may also be noted (Wolf et al., 1956).

CHRONIC TOXICITY: Benzene has been associated with hematologic effects in occupationally-exposed humans. Adverse human effects include anemia, leukopenia and thrombocytopenia. Chronic benzene exposure may lead to a decrease in all circulating cells (pancytopenia) or failure to manufacture blood cells altogether (aplastic anemia) (Goldstein, 1977). These effects are hypothesized to be related to the metabolites of benzene acting on the precursors of circulating blood cells formed in the bone marrow. Because the toxic effect is difficult to simulate in experimental animals, the mechanism of this action has been difficult to determine.

Ingestion: In humans, chronic exposure to benzene by ingestion is rare. However, Schwarz (1932) reported the clinical picture and progress of a 28-year-old male who ingested a gasoline/water mixture for several months as a self administered remedy for hypochondriacal gonorrhea. Severe weakness, muscular atrophy and polyneuritis with weak or absent reflexes developed. A slow recovery followed the discontinuation of gasoline ingestion, with hospital discharge after seven months. (It can be speculated that the benzene content of the gasoline at that time was probably between 5 - 8%. However, part of the neuromuscular effects noted in this case history might also be attributed, in part, to the n-hexane content of gasoline).

Inhalation: Chronic occupational exposure to benzene has resulted in adverse hematologic effects, including anemia, leukopenia, thrombocytopenia, aplastic anemia, and leukemia.

Lifetime inhalation exposure to 100 or 300 ppm (348 or 1,045) benzene by rats and mice resulted in lymphocytopenia, anemia, and decreased survival time (Snyder et al., 1978). Later evaluation of the same study showed preliminary evidence of carcinogenicity (U.S. EPA, 1987). There is a growing body of evidence that suggests that benzene produces leukemia in Sprague-Dawley rats (Goldstein et al., 1982).

Skin contact: Dermal absorption of benzene is considerably less than the absorption by inhalation. Hemotoxicity in humans or animals by dermal contact alone does not appear to have been reported (ATSDR, 1987).

Eye contact: see "Eye contact" under ACUTE TOXICITY.

SENSITIZATION: Eosinophilia, an indication of an allergic response, has been noted in several workers chronically exposed to benzene by a number of investigators (Aksoy et al., 1971).

TARGET ORGAN EFFECTS: The most significant effects of benzene are disruption of hematopoiesis, neurotoxicity, and increases in the risk of some forms of hematopoietic cancer.

ABSORPTION-METABOLISM AND EXCRETION: Benzene can be absorbed into the body by inhalation, ingestion or dermal contact. It is highly lipid soluble, and therefore tends to distribute to fatty

tissues (U.S. EPA, 1987). After ingestion, approximately 90% of the administered dose is absorbed. Following inhalation, it is estimated that 50% of a continuous dose is absorbed (Nomiyama and Nomiyama, 1974a;b). Blank and McAuliffe (1985) calculated that a working adult would dermally absorb 1.5 □l/hr from whole body exposure ($2m^2$) to an atmosphere of 10 ppm benzene, while 7.5 □l/hr would be absorbed by the lungs under the same conditions. NIOSH calculated that a worker in direct contact with petroleum naphtha in tire manufacturing could absorb approximately 6 mg through the intact skin (US OSHA, 1985). In the rhesus monkey or hairless mouse, dermal absorption was reported to be <1% after a single direct application but did increase with repeated administration (Maibach and Anjo, 1981).

Both human and animal studies indicate that benzene must undergo metabolic transformation to exert its toxic effect on the hematopoietic system. The liver and the bone marrow contain the enzymes necessary for the metabolic transformation of benzene to benzene oxide, hydroquinone, phenol, catechol and trans, trans mucondialdehyde. The metabolites of catechol, p-benzoquinone, hydroquinone and phenol are known to cause lymphoid tissue suppression. Administration of benzene to rats, dogs, rabbits, and mice via inhalation and/or ingestion results in its rapid uptake and excretion, mainly via exhalation of unchanged benzene (Rickert et al., 1979; Parke and Williams, 1953; Andrews et al., 1977). In humans, the elimination of benzene is biphasic, with approximately 16% eliminated unchanged via exhalation within 5 hours (Nomiyama and Nomiyama, 1974a, 1974b). The remaining benzene is stored in fatty tissue and is excreted slowly .

REPRODUCTIVE TOXICITY: There is no evidence that benzene is teratogenic. However, benzene has been shown to be a growth inhibitor in utero (U.S. EPA, 1983) and show embryotoxic/fetotoxic effects at dose levels that are also maternally toxic (ATSDR, 1987). CD-1 mice exposed to 300 ppm benzene vapor , 6 hrs./day, 5 days/week for 13 weeks demonstrated bilateral ovarian cysts, decreased sperm counts with an increase in deformed sperm, and testicular atrophy and degeneration (Ward et al., 1985). Testicular degeneration was also noted in rabbits exposed to 80 ppm (Wolf et al, 1956) while the exposure of female rats to 210 ppm 10 days prior to mating and for 3 weeks after mating resulted in a complete absence of litters (Gofmekler, 1968).

Female workers exposed to levels in excess of 30 ppm developed menstrual disturbances and possibly decreased fertility (Barlow and Sullivan, 1982). The levels of exposure in this study exceeded the levels of exposure commonly seen in the present day workplace (ATSDR, 1987).

NEUROTOXICITY: Acute neurotoxic effects of benzene include: drowsiness, dizziness, headache, delirium, and perhaps loss of consciousness. These neurological effects are believed to be due directly to benzene and not any of its metabolites (ATSDR,1987).

Incident reports on low level, chronic exposures have suggested that benzene may produce a neurasthenic syndrome and polyneuritis. The neurotoxicity of benzene has not been extensively studied, perhaps owing

to the fact that the chronic exposure to benzene and the associated hematoxicity may mask any neurotoxic effects (Sandmeyer, 1981).

IMMUNOTOXICITY:

Benzene-induced hematoxicity involves the erythroid, myeloid and lymphoid lineages of blood cells, of which the lymphoid line appears to be the most susceptible. Inhalation exposure of mice to 300 ppm, 6 hr/day for 115 exposures impaired the ability of T and B cells to respond to mitogenic stimuli with a marked reduction in the number of B-lymphocytes in the bone marrow and spleen and the T-lymphocytes in the thymus and spleen. B cells were considered to be more sensitive than T cells (Rosen and Snyder, 1985). These same authors also studied host resistance to infection with *Listeria monocytogenes* and concluded that benzene exposure delays the cell mediated immune response.

Other immunosuppressive effects attributed to benzene exposure include a depression of antibody formation in mouse spleen cells (Wierda et al., 1981) and a reduction in the number of circulating B-lymphocytes (Irons and Moore, 1980). In the spleen, benzene metabolites are cytotoxic and reduce the total number of cells as well as progenitor cells in the spleen and bone marrow.

GENOTOXICITY:

Benzene has been shown to be non-mutagenic in *Drysophila melanogaster* and in several in vitro assays. However, benzene oxide, the presumed initial metabolite of benzene, is mutagenic without activation in the Ames Test (U.S. EPA, 1987). Morimoto and Wolff (1980) observed that hydroquinone and catechol increased the frequency of sister chromatid exchanges in human lymphocytes. Tunek et al., (1980) identified hydroquinone as the principal metabolite responsible for binding benzene in rat liver microsomes. Pfeiffer and Irons (1981) reported that hydroquinone and benzoquinone inhibited lymphocyte mitogenesis at concentrations that did not produce cytotoxicity.

CARCINOGENICITY:

Benzene has been classified as a human carcinogen by IARC, NTP, EPA and OSHA based on the results of epidemiologic studies. Benzene is among the few substances given an "A" weight of evidence rating by the EPA indicating there is adequate/sufficient data from human studies to show that the compound is classified as a carcinogen.

An association between benzene exposure and lymphatic and hematopoietic cancer (particularly leukemia) has been documented in epidemiologic studies (McMichael, 1988). Acute myelogenous leukemia (AML) is most frequently associated with benzene exposure. Ott et al. (1978) examined long-term mortality in a cohort of 594 workers occupationally exposed to benzene at the Michigan Division of Dow Chemical Company. Estimates of cumulative benzene exposures were based on work histories and industrial hygiene records. Fifty-three individuals who experienced concomitant exposure to arsenicals, asbestos, or high vinyl chlorides were analyzed separately. Among the remaining cohort, observed deaths were less than expected based on U.S. white male mortality, with no statistically significant increases due to any cause of death. Three cases of leukemia were observed (two cases of acute myelogenous leukemia, one case of chronic myelogenous leukemia). Based on Third National Cancer survey data, the expected incidence of myelocytic leukemia was 0.8 cases. A clear dose-response relationship

between benzene exposure and leukemia could not be established.

The mortality experience of workers exposed to benzene during the manufacturing of rubber hydrochloride has been reported by Infante et al. (1977a&b) and Rinsky et al. (1981). A five-fold increase in risk of developing leukemia of any type and a ten-fold excess in deaths attributable to myelogenous and monocytic leukemia were observed (Infante et al., 1977a). Two control populations were used as comparative standards: the general U.S. male population and a non-exposed working male (N = 1447) population. After strong criticism of study methodology from Tabershaw and Lamm, Infante et al. (1977b) re-analyzed their own data using Tabershaw and Lamm's suggested methodology. The re-calculated risk was 8.5- fold versus the original ten-fold risk for excess deaths due to myelogenous and monocytic leukemia.

Rinsky et al. (1981) examined data from the occupational cohort of rubber workers followed by Infante et al. (1977a). Analysis was based on a 98% complete vital status follow-up. Although the Rinsky et al. study was limited in its characterization of exposure, the authors concluded that a dose-response relationship between benzene exposure and leukemia exists. Because dermal exposure was not measured, and anecdotal evidence of significant dermal exposure exists (i.e., workers drenched in benzene during some of the operations), the authors may have underestimated benzene exposure and subsequently overestimated the quantitative leukemia risk (Wong, 1987).

Wong (1987) investigated mortality patterns among 7,676 chemical workers from seven plants exposed to benzene. As compared to chemical workers with no benzene exposure, workers continuously exposed to benzene experienced an increased risk of hematopoietic cancer (Standard Mortality Ratio = 320, $p < 0.05$).

EPIDEMIOLOGY: Epidemiologic studies of cohorts occupationally exposed to benzene have found increases in deaths due to lymphatic and hematopoietic cancer. Findings are reviewed under CARCINOGENICITY.

ENVIRONMENTAL FATE: Benzene in the atmosphere is not directly photolyzed but does react with photochemically produced hydroxyl radicals. The estimated half-life is of the order of a few days. The reaction time in polluted atmospheres which contain nitrogen oxides is estimated to be four to six hours (HSDB, 1989).

Benzene has been shown to undergo microbiological biodegradation both aerobically and anaerobically. Under aerobic conditions, effective biodegradation can occur within 7 days to several months. Anaerobic degradation is somewhat longer; reportedly 6 months to 2 years (ATSDR, 1987).

ENVIRONMENTAL TOXICITY: Benzene is ubiquitous in the environment. It has been identified in soils, water supplies, finished water, indoor and outdoor air, cigarette smoke and foods.

Outdoor ambient air levels range from 0.2 ppb to a high of 60 ppb in Tuscaloosa, Alabama and Pittsburgh, Pennsylvania. More common

values for large cities are in the range of 10 to 30 ppb. Indoor air in Elizabeth and Bayone, New Jersey have reached a maximum of 158 ppb.

Environmental lethal dose concentrations for aquatic species are presented in Table 2.

Table 2.

Environmental Lethal Dose Concentration

Species	Value	Dose	Time
Bluegill Sunfish	LD_{50}	29 mg/l	24-48 hr.
Bluegill Sunfish	LD_{100}	34 mg/l	24 hr.
Gold fish	LD_{50}	46 mg/l	24 hr.

(Reference: Verschueren, 1983)

REGULATORY STATUS:

The U.S. EPA and IARC (International Agency for Research on Cancer, 1982) has classified benzene as a Group A (human carcinogen) in its weight of evidence classification system based on sufficient human evidence of carcinogenicity. The EPA Cancer Assessment Branch, using the data from three epidemiological studies (Rinsky et al., 1981; Ott et al., 1978 and Wong et al., 1983) and a linear dose-response model, has calculated a cancer potency factor of 2.90×10^{-2} $(mg/kg/day)^{-1}$ for both oral and inhalation routes of exposure (IRIS, 1986). These studies are based on historic reconstructions of exposure scenarios dating from approximately 1940 to 1971 and attempt to show a correlation between benzene exposure and increased incidences of myleogenous leukemia in occupationally exposed workers. Reconstruction of exposure scenarios are based on personnel data, job descriptions and other anecdotal reports. Since these investigations were not designed to support epidemiological studies but rather to identify problems with regulatory compliance, some data gaps exist. Results from these studies are inconclusive at this point.

The California Air Resources Board has established a range for the cancer potency factor of 2.65×10^{-2} to 1.85×10^{-1} $(mg/kg/day)^{-1}$ (CARB, 1989). The unit risk values for this range are 7.5×10^{-6} to 5.3×10^{-5} (CAPCOA, 1990). The cancer unit risk for drinking water is 8.3×10^{-7} per □g/L based on a one-hit extrapolation method and on the assumption that an adult human consumes 2 liters of water per day (IRIS, 1990). The unit risk factor is defined as the additional risk of cancer death associated with drinking water containing 1 μg/L or breathing air containing 1 $\mu g/m^3$ of benzene. The EPA has not established an RfD (IRIS, 1989). The exposure limit values listed or recommended by different agencies are presented in Table 3.

Table 3. Worker Exposure Limits

ACGIH TLV:	10 ppm (30mg/m^3) A-2 carcinogen
STEL:	N/A
OSHA PEL:	1 ppm (3.5 mg/m^3)
IDLH:	N/A
NIOSH REL:	N/A
MSHA:	N/A

N/A - not available
(References: ACGIH, 1988; NIOSH, 1985)

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TOXICOLOGY UPDATE

Title:	**VINYL CHLORIDE**
Synonyms:	choloroethene, chloroethylene, vinyl chloride monomer, VCM, vinyl C monomer, ethylene monochloride, monochloroethylene.
CAS number:	75-01-4
Boiling Point:	-13.37 °C
Color:	Colorless liquid or gas
Conversion factor:	1 ppm = 2.60 mg/m^3
DOT designation:	Flammable gas
Flammability limits:	
Autoignition:	472°C
Flashpoint:	NA
LEL:	4%
UEL:	22%
Henry's Law Constant:	1.2 atm.m^3/mol.@10°C
Melting Point:	-153.8°C
Molecular formula:	C_2H_3Cl
Molecular weight:	62.50
Odor:	
Threshold:	3.4 ppm (air), 3000 ppm (water)
Recognition:	NA
Characteristics:	Faintly sweet odor
Solubility:	
water:	1100-2763 mg/l @ 25°C
Kow:	1.38
other:	very soluble in ether, soluble in alcohols and hydrocarbons.
Koc:	57 ml/g
Specific gravity:	0.9106 (20/4 °C)

Vapor density: 2.15 (air = 1)

Vapor pressure: 2530 mm Hg @ 20°C

Viscosity:. 0.01702 cP @ 20°C (gas); 0.280 cP @ -20°C (liquid)

NA = not available
(references 1,2,3)

COMPOSITION:

Vinyl chloride is a volatile chlorinated hydrocarbon, which, at room temperature is a colorless gas having a mild, sweet odor. It is typically supplied as a pressurized liquid of technical grade 99% purity[4]. Phenol is used as a stabilizer to prevent polymerization of vinyl chloride and is generally added at levels of 25-50 mg/kg of vinyl chloride.[5].

USES/SOURCES:

Vinyl chloride can be produced by thermally cracking ethylene dichloride or by chlorinating ethylene[6]. The vinyl chloride monomer is polymerized into polyvinyl chloride and used in the plastics industry to make a variety of products, including food covering, pipe, wire coating, furniture, housewares, wallcovering, packaging materials, auto upholstery and auto parts. A vinyl chloride-vinyl acetate copolymer is used in floor coverings, phonograph records and flexible film. A vinyl chloride-vinylidine chloride copolymer is used in food packaging film. Vinyl chloride is also used as a refrigerant gas and as a chemical intermediate. It was formerly used in small amounts as an aerosol propellant and an ingredient in drugs and cosmetics[2].

Vinyl choride has the potential to migrate from PVC packaging into food (e.g., bottled drinking water). The migration rate appeared to be linear, and estimated exposure may exceed 100 ng/person/day[7].

ACUTE TOXICITY:

Ingestion:

Ingestion is an unlikely route of exposure despite the water solubility of this compound due to the extremely high vapor pressure. However, the LD50, by gavage in rats is reported to be 500 mg/kg[6].

Inhalation:

Vinyl chloride may be tolerated at levels over 8000 ppm for up to 5 minutes without developing signs or symptoms of toxicity[8]. Inhalation of vinyl chloride may cause respiratory irritation, bronchitis, dizziness, incoordination, headache, irritability, afferent sensory polyneuritis, cardiac arrythmia, unconsciousness and death. Pulmonary effects include dyspnea, asthema, interstitial pneumonitis and pneumonoconiosis[8]. Vinyl chloride impairs the central nervous system (CNS) at high concentrations. Deaths in humans due to narcosis have been reported. However, the concentrations were unquantified[2]. Slight anesthesia, drowsiness, slight

visual disturbances, faltering gait, numbness and tingling in the extremities have been observed at 1000 ppm[9]. Inhalation of vinyl chloride at concentrations ranging from 8,000-20,000 ppm may produce dizziness, giddiness, euphoria, ataxia, headache and narcosis[10].

The acute LC50 levels for rodents are presented in Table 1. Anesthesia was observed in dogs at 70,000 ppm[11]. Pulmonary edema, hemorrhaging, impaired blood clotting, and liver and kidney congestion were also observed in laboratory animals following acute exposure to vinyl chloride[12].

Eye Contact: Vinyl chloride is a severe irritant to the eyes and mucous membranes[6]. Data regarding acute toxicity from eye contact was not located but effects associated with its ability to freeze tissue might be expected.

Skin Contact: Liquid vinyl chloride placed on the skin may freeze tissue and produce a chemical burn as it evaporates, causing damage to the underlying tissue (frostbite). This chemical is considered to be a severe skin irritant[6]. Data regarding acute toxicity from skin contact was not located. Significant absorption from incidental skin contact is unlikely to result in systemic toxicity due to the volatility of the compound.

CHRONIC TOXICITY:

Ingestion: The liver is the primary target organ for vinyl chloride in humans and animals. Toxic effects in animals subject to chronic ingestion of vinyl chloride include enlargement of the liver and spleen, reduced blood clotting time and development of angiosarcomas, adenosarcomas and heptacellular carcinomas[14]. Feron et al.,[15] determined 30 mg/kg to be the No Adverse Effect Level (NOAEL) and 100 mg/kg to be the Lowest Acverse Effect Level (LOAEL) in rats based upon liver effects during a 15 week gavage study. Slight histological changes in the hepatocytes were observed in the 100 mg/kg and 300 mg/kg dose levels. Hypertrophy of the rough endoplasmic reticulum was observed in both sexes in the 300 mg/kg dose group. A dose-related increase in liver weights was also observed with differences being significant in the 300 mg/kg dose level.

A lifetime feeding study by Til et al.,[16] found the NOAEL and LOAEL to be 0.13 mg/kg/d and 1.3 mg/kg/d, respectively, based upon hepatotoxicity. Heptacellular changes and hepatic cysts were observed in both sexes receiving 1.3 mg/kg/d. An increase in basophilic foci was observed in both sexes receiving 1.3 mg/kg/d but only in females receiving 0.13 mg/kg/d and 0.014 mg/kg/d. The authors concluded that histopathologic effects observed at 0.13 mg/kg/d and 0.014 mg/kg/d were compound-related but not considered to be adverse effects. Feron et al.,[17] also observed hepatic effects including preneoplastic changes in all treatment groups receiving dietary polyvinyl chloride at levels between 1.7

- 14.1 mg/kg/d. Thus the minimal risk level or Hazard Index, based upon hepatotoxicity, is estimated to be approximately 0.0013 mg/kg/d[18] after applying a standard default safety factor of 100 to the NOAEL determined by Till et al.,[16].

Inhalation:

Occupational exposure to vinyl chloride vapor has resulted in deaths due to narcosis and development of conditions known as "vinyl chloride disease" and "meat wrapper's asthma"[8,18,19]. Vinyl chloride disease has been reported in workers exposed to several hundred ppm for periods ranging 1 month to 3 years before the onset of symptoms[8]. Symptoms of vinyl chloride disease include scleroderma of the connective tissue in the fingers with dermal thickening, a Raynaud-like condition with reversible arteriole constriction, causing numbness, pallor and cyanosis of the fingers. This condition may be followed by acroosteolysis (dissolution of the ends of the distal phalanges of the hand). Hematologic, respiratory and hepatic effects, and increases in circulating IgG and immune complexes have also been observed[20,21]. However, no new cases of vinyl chloride disease have been reported in the U.S. since 1974 when the occupational exposure levels were reduced to 1 ppm[8].

Hepatotoxicity was observed in mice found dead after subchronic exposure (5-9 days) to 1000 ppm vinyl chloride[22]. Suzuki et al.,[23,24] observed proliferative hypertrophy of terminal bronchiolar cells, hyperplasia of alveolar epithelium, degeneration of alveolar septal cells and peribronchiolar or bronchiolar inflammation in mice exposed to 2500 ppm or 6000 ppm during a six month period. Rats exposed to 5000 ppm for one year were observed to have hematologic effects, reduced growth, increased splenic hematopoiesis, degeneration of the myocardium, thickening of the arterial walls, hyperplasia of the olfactory epithelium, nephrotoxicity and mild alteration of the lungs and zymbal glands[25].

The LOAEL in a six month rat subchronic study was found to be 10 ppm based on hepatic effects[26]. The LOAEL based upon hepatic effects in a one year rat study was at 50 ppm, the lowest dose level. Consequently the NOAEL could not be determined[22]. A subsequent one year rat study by Bi et al.,[26] found the LOAEL and NOAEL to be 100 ppm and 10 ppm, respectively, based upon terminal body weights. The minimal risk level for "intermediate exposures" to vinyl chloride is estimated to be 50 ppm based on this data[18].

Eye Contact:

See ACUTE TOXICITY, Eye contact.

Skin Contact:

See ACUTE TOXICITY, Skin contact.

SENSITIZATION:

No information regarding the skin sensitization potential of vinyl chloride was located. However, Meat wrapper's asthma is thought to be attributed to the thermal degradation products emitted from heat sealed vinyl

chloride wrapping materials[19].

TARGET ORGAN TOXICITY:

Cardiovascular Effects:

Impaired circulation in the extremities and Raynaud's Syndrome have been observed in humans suffering from "vinyl chloride" disease. Mild focal degeneration of the myocardium, portal hypertension, thickening of the arterial walls and tumors of the hepatic blood vessels have been observed in rats subject to chronic vinyl chloride exposure[27].

Vinyl chloride has sensitized the animal heart to epinephrine-induced arrythmias and may increase ventricular fibrillation[9].

Increased spleen weight, thrombocytopenia and changes in hematology parameters were observed in rats exposed to high levels of vinyl chloride for one year[25].

Hepatic Effects:

Vinyl chloride has been associated with hepatotoxic effects in humans and animals. Signs of vinyl chloride liver injury include abdominal pain, weight loss, fatigue and weakness. Fibrosis and cirrhosis may occur and cause hepatomegaly, splenomegaly, portal hypertension, thrombocytopenia and esophogeal varices[22,28]. Hepatic fibrosis is often observed in the tumor-free portions of liver in workers dying from angiosarcoma. However, the transition from hepatic fibrosis to angiosarcoma has not been proven[8].

Increased levels of urinary porphyrin and coproporphyrin correlate with liver damage induced by vinyl chloride and other hepatotoxins[29]. Hepatotoxic effects may be reversible in occupationally exposed individuals. Between 1971 and 1982, 12 of 13 workers in a vinyl chloride polymerization plant were observed to have persistent abnormalities in one or more liver function tests. The vinyl chloride levels during this period ranged from 1-21 ppm. In 1983 the vinyl chloride level was maintained below 1 ppm and no further cases of vinyl chloride-induced liver dysfunction were observed[30].

Scleroderma on the back of the hand at the metacarpal and phalangeal joints and inside of the forearms has been observed in some chronically exposed indviduals having angioneurotic disorders[9].

In experimental animals, Torkelson et al. (1961)[31] observed hepatic lesions in rabbits and rats exposed for 6 months to 500 ppm and 200 ppm, respectively. Lee et al.,[22] reported increased hepatic cell turnover rates in rats exposed to 50 ppm for 8-9 months. No inhalation NOAEL for hepatotoxic effects has been reported. The ATSDR holds 50 ppm to be a Frank Effect Level (FEL)[18]. Development of hepatotoxicity via ingestion of vinyl chloride appears to be significantly related to the duration of

exposure given that the subchronic oral NOAEL is 30 mg/kg[15], over 200 times greater than the chronic oral NOAEL of 0.13 mg/kg/d[16].

The liver is the primary target of vinyl chloride effects because it is believed that vinyl chloride is biologically activated in the liver by cytochrome P-450 IIE1 in the mixed function oxidase system[32]. The mixed function oxidase system oxidizes vinyl chloride into the reactive oxirane, 2-chloroethylene oxide. The oxirane then reacts and covalently bonds to nearby macromolecules, such as proteins or nucleic acids impairing cell function or causing mutations. This hypothesis is supported by studies showing vinyl chloride metabolites covalently bound to macromolecules and vinyl chloride hepatotoxicity potentiation by P-450 inducers and suppression by P-450 inhibitors[32, 33].

Vinyl chloride has recently been implicated as a "suicide inhibitor" of cytochrome P-450. Following activation by P-450 the reactive oxirane covalently binds to pyrrole nitrogens in the heme moiety, destroying the heme and reducing P-450 activity[34].

ABSORPTION-METABOLISM-EXCRETION: Absorption in rats from the gastro-intestinal tract is nearly complete, ranging between 80-90%[35]. Withey[36] found blood levels peaked 10-20 minutes following gavage of a single 10 ml aliquot of 44-92 mg/kg vinyl chloride in an aqueous solution. Seventy-two hours after ingestion, the greatest concentration of vinyl chloride was found in the liver at concentrations 2-5 fold greater than in the lung, fat, muscle, skin or plasma[35].

On average, humans retain 42% of inhaled vinyl chloride[37]. Animal data indicates that vinyl chloride is rapidly absorbed, but is insufficient to quantitate the proportion of dose absorbed[18]. Buchter et al.,[38] found that when metabolism was inhibited with 6-nitro-1,2,3-benzothiadiazole the greatest levels of labeled vinyl chloride occurred in the fat. However, when metabolism was not inhibited the greatest levels of vinyl chloride were found in the liver and kidneys. Duprat et al.,[39] conducted a study measuring tissue concentrations in rats of radio-labeled vinyl chloride following exposure to 20,000 ppm. Ten minutes after exposure radioactivity was detected in the liver, bile duct, digestive tract and kidney. In rats, radio-labeled vinyl chloride was detected in order of decreasing activity in the liver, kidney, skin, lung, carcass, plasma and fat[35].

Dermal absorption of vinyl chloride in animals is minimal at best. The bodies of rhesus monkeys were placed in a chamber in which they were exposed to 800 and 7000 ppm vinyl chloride while their heads were outside of the chamber, permitting only dermal absorption. At 800 ppm dermal absorption was 0.031% and 0.023% at 7000 ppm[40].

Metabolism of vinyl chloride is believed to proceed by three alternative pathways; the extent of each is dependent upon vinyl chloride concentration. At low concentrations, the primary pathway appears to be sequential oxidation of vinyl chloride to 2-chloroethanol, 2-chloroacetalaldehyde, and finally to 2-chloroacetic acid by alcohol dehydrogenase. Pretreatment with ethanol at exposure levels of less than 100 ppm resulted in inhibition of greater than 83%. However, pretreatment with ethanol prior to exposures of 1000 ppm resulted in inhibition by less than 47%, suggesting an alternative metabolic route to the alcohol dehydrogenase pathway[18].

At greater concentrations, vinyl chloride may be oxidized by mixed function oxidases to 2-chloroethylene oxide, with spontaneous rearrangement to 2-chloroacetalaldehyde, or oxidized by catalase to 2-chloroethylhydro-peroxide, followed by dehydration to form 2-chloroacetalaldehyde. Pretreatment with SKF-525A had no effect on vinyl chloride metabolism at concentrations less than 100 ppm. Metabolism of vinyl chloride was inhibited by 19% with SKF-525A pretreatment at exposure levels of 1000 ppm, indicating the MFO pathway is significant only at higher concentrations[40].

However, pretreatment with 6-nitro-1,2,3-bezothiadiazole completely inhibited vinyl chloride metabolism in rats exposed to 0.45 ppm vinyl chloride for 5 hours, suggesting metabolism via the alcohol dehydrogenase pathway may require epoxidation by mixed function oxidases[32]. Buchter et al.,[41] found saturation of the metabolic pathways in rhesus monkeys to occur at 200 ppm and a Vmax of 50 umol/hr/kg, which is less than that observed in rats exposed to 250 ppm with a Vmax of 110 umolh/kg[42].

Vinyl chloride is believed to be metabolized into a reactive epoxide intermediate (see CHRONIC TOXICITY, Hepatic Effects). A subsequent metabolite, 2-chlororacetalaldehyde readily conjugates with sulfhydryl groups in proteins. If the glutathione-S transferase (GSH) detoxification pathway is saturated, then the aldehyde is free to bind to other proteins, impairing cell function.

The route of excretion is determined by the extent of exposure regardless of whether exposure is via ingestion, inhalation or interperitoneal or intravenuous injection. Generally, as the dose increases the proportion of unchanged vinyl chloride exhaled also increases[43]. At low exposure levels, the majority (~70%) of vinyl chloride is excreted in the urine[39].

Exhalation of unchanged vinyl chloride is not a significant route of elimination by humans from exposure to low concentrations. Individuals were exposed to 2.9-23.1 ppm vinyl chloride for 6 hours and breath samples were taken 30 minutes following exposure. Mean concentrations of exhaled vinyl chloride ranged from undetectable to 1.1 ppm[37].

GENOTOXICITY: Vinyl chloride has tested positive in in vitro and in vivo mutagenicity assays. The mutagenicity data implicates 2-chloroethylene oxide and 2-chloroacetalaldehyde as being the mutagenic agents associated with the positive results. Both metabolites have been shown to be more effective than vinyl chloride in inducing mutations in S. typhimurium[44]. Metabolic activation of vinyl chloride has been required to obtain maximal or any response[45]. Vinyl chloride has been shown to be mutagenic in S. typhimurium strains which revert by base-pair substitutions from alkylating agents rather than frame-shift reversion strains[46]. Singer et al.,[47] found that N 2,3-ethenoguanine is a product of vinyl chloride reaction with DNA in vivo and of the chloroacetalaldehyde in vivo. This reaction led to increased G-A transition with E. coli and D. melanogaster polymerases, and HIV reverse transcriptase.

Vinyl chloride was positive in the recessive lethal assay, but negative in the dominant lethal assay in D. melanogaster[48]. Vinyl chloride was negative in the mouse dominant lethal assay[49]. Vinyl chloride has been found to alkylate DNA in rats and mice[50,51].

Chromosomal aberrations in human peripheral lymphocytes of exposed workers have been detected in many studies and breaks have been reported to be localized in specific chromosomes[52,53]. Anderson et al.,[54] observed a decrease in chromosomal aberrations in exposed workers following a reduction in exposure from 50 ppm to less than 5 ppm.

NEUROTOXICITY: Inhalation of vinyl chloride produces anesthesia and narcosis. Chronic occupational exposure to levels less than 50 ppm has been associated with distal axonal neuropathy in the legs[55] and changes in electroencephalographs of workers exposed to vinyl chloride and other solvents[56].

Diffuse degenerative lesions in the grey and white matter of the brain and atrophy of cerebellar granular layer in rats exposed to 30,000 ppm for 4 hrs/d for 5 d/week has been reported[57]. Other neurotoxic effects include functional disturbances of the CNS with afferent sensory polyneuritis[58]. Brain neuroblastomas have been observed in chronic rat inhalation studies[15].

REPRODUCTIVE TOXICITY: Epidemiologic data shows a possible correlation between paternal occupational exposure to vinyl chloride and fetal loss[59,60]. An increase in CNS defects, deformaties of the upper alimentary and genital tracts, and clubfoot were observed in stillborn and live children in three cities having vinyl chloride plants[5].

Animal teratogenicity data is equivocal. No adverse maternal or teratogenic effects were observed in rats exposed to over 500 ppm for 7 to

12 day intervals during organogenesis[61,62]. However, Mirkova et al.,[63] observed evidence of fetotoxicity and teratogenicity in rats subject to continuous exposure of 2.4 ppm. Evidence of fetotoxicity included early post implantation loss, reduced fetal weight, retarded ossification and fetal hematomas. Evidence of teratogenicity included anomalies of the brain and impaired liver functions.

Occupational exposure has been found to be associated with impaired sexual function in both sexes and impaired gynecological health in women in a Russian study. Ovarian dysfunction, benign uterine growths and prolapsed organs were reported in 77% of exposed women[64]. Bi et al.[26] observed a significant reduction in testicular weight in rats exposed to 100 ppm and 300 ppm for 6 months.

CARCINOGENICITY:

Vinyl chloride has been associated with cancer in humans and has been classified as a Group 1 carcinogen by IARC and a Group A carcinogen by the EPA[65].

Vinyl chloride was first associated with liver cancer in exposed workers in 1974 when rare liver angiosarcomas were detected in three workers in a single vinyl chloride polymerization plant[66]. Based upon a worldwide register of cases of angiosarcoma, the average length of exposure resulting in angiosarcoma is 18.3 years[8]. Fibrosis is typically found in tumor-free portions of the liver in workers dying of angiosarcoma, but transition from fibrosis to angiosarcoma has not been proven[8]. After 1974 occupational exposure levels were reduced to 1 ppm. No cases of hepatic angiosarcoma in workers exposed soley after this date have been recorded. However, a longer latency period may be required. Data on cases of angiosarcoma allegedly due to environmental contamination are equivocal due to background incidence and insufficient sample size[8].

Vinyl chloride has been implicated in other forms of cancer. Increased incidence of brain, respiratory tract, and digestive tract, hematopoietic/lymphopoietic cancers, and malignant skin melanomas have been associated with occupational vinyl chloride exposure[67,68].

Inhalation and ingestion of vinyl chloride has produced cancer in laboratory animals. Maltoni et al.,[69] observed an increased incidence of tumors in mice, rats and hamsters exposed to $\geq$ 50 ppm. Liver angiosarcoma increased in all species; hepatomas, zymbal gland carcinomas, neuroblastomas, extra-hepatic angiosarcomas and skin acanthomas were also noted. Drew et al.,[70] detected an age effect upon carcinogenic response to vinyl chloride exposure in mice, rats and hamsters. Maximal carcinogenic response occurred if inhalation exposure was during the first year of life. Rats were also observed to have biologically significant increased incidence of brain cancer[25,69]. Lung tumors were frequently observed in mice as the primary carcinogenic

response following acute and chronic exposure[71,72].

EPIDEMIOLOGY:

Occupational exposure to vinyl chloride has been associated with an increased incidence of cancer, particularly liver angiosarcoma[66]. A recent Scandanavian study detected a nearly three-fold increase in liver cancer among vinyl chloride workers which clearly correlated to time of initial exposure, duration of employment and estimated quantitative expsoure[73]. Other cancers associated with occupational vinyl chloride exposure include cancer of the brain/CNS, lung/respiratory tract digestive tract, pancreas, and hematopoietic/lymphocytic system, and malignant skin melanoma[67,68]. Cutaneous and epithelioid hemangioendotheliomas have also been reported in occupationally exposed individuals[74,75].

A syndrome known as "vinyl chloride disease" has been associated with occupational exposure (See CHORNIC TOXICITY, Inhalation).

ENVIRONMENTAL FATE:

Air: Nearly all vinyl chloride released into the environment reaches the atmosphere due to its volatility. The primary sources of release are vinyl chloride and polyvinyl chloride manufacturers. Prior to 1975, an estimated 100 million kg/yr were released by PVC plants[5]. Hartmans et al.,[76] estimated 400 million lbs. of vinyl chloride were released worldwide during 1982. Other sources include release from landfills, combustion of PVC and tobacco smoke[5,77].

Photodegradation of vinyl chloride in a reaction with hydroxide radicals is the primary means of removing vinyl chloride from the air. EPA[2] estimates the half-life to be approximately 1.5-1.8 days. Breakdown products include hydrochloride, formaldehyde, formyl chloride, carbon monoxide, carbon dioxide, chloracetalaldehyde, acetylene, chloroethylene, chloroacetylchloranil and water. In areas of photochemical smog the half-life is substantially shorter, approximately 3-7 hours[9]. Reaction with ozone, oxygen atoms and direct photolysis are insignificant degradation mechanisms[2].

The high partition coefficient between air and water probably makes removal of vinyl chloride from air by wet deposition insignificant. Dry deposition is equally insignificant due to the high vapor pressure of vinyl chloride[2].

Water: Vinyl chloride volatizes from water relatively rapidly. The estimated half-life of vinyl chloride in a pond, lake and river is 43.3, 34.7 and 8.7 hours, respectively[2]. However, Lyman et al.[78] estimated the half-life to 0.805 hours. This estimate was based upon a Henry's Law contant of 0.0560 atm/m^3, a 1m deep stream, 3 m/sec current, and a wind velocity of 3m/sec. Factors affecting half-life include reaeration rates and salt

concentration. Photodegradation may be a significant removal mechanism in waters containing photosensitizers, such as humic acids[9].

Chemical hydrolysis or oxidation is not expected to be a significant degradation mechanism. Microbial degradation under aerobic conditions has been shown to be insignificant[2]. However, biodegradation may be an important mechanism in groundwater where volitization can not occur. Under aerobic conditions 99% of radiolabeled vinyl chloride was degraded after 108 days in an acquifer, 65% was converted to carbon dioxide[79]. Degradation products in groundwater also includes trichloroethylene, tetrachloroethylene and 1,1,1-trichloroethane[80].

Soil: Vinyl chloride is expected to volatize readily from dry or wet soil due to its high vapor pressure. The half-life of vinyl chloride placed in 1 cm and 10 cm of dry soil is estimated to be 2 1/2 hours and 12 hours, respectively[2].

The soil adsorption coefficient (Koc) for vinyl chloride is estimated to range between 17-131, indicating high soil mobility and potential to reach groundwater[78,81].

ENVIRONMENTAL TOXICITY: Based solely on water solubilty, vinyl chloride is estimated to have a bioconcentration factor (BCF) of 7. Thus, vinyl chloride is not expected to be significantly bioconcentrated in aquatic orgamisms. Other studies suggest that the high vapor pressure and rapid volatization from water precludes bioconcentration except in large releases [82] and estimation of the median threshold limit (TLm) for aquatic species.

REGULATORY STATUS: Vinyl chloride is an IARC and EPA carcinogen. However, OSHA does list permissible exposure levels (PELs) which are presented in Table 2.

Risk Assessment: The EPA[65] estimated unit risk factor is 6.6×10^{-5} per ppb. The EPA[82] estimates risk based on vinyl chloride ingestion as follows:

Risk	2 l of water	6.5 g of fish
10-5	20 ug/l	5246 ug/l
10-6	2.0 ug/l	525 ug/l
10-7	0.2 ug/l	52.5 ug/l

Air: Vinyl chloride has been classified as a hazardous air pollutant by the EPA pursuant to section 112 of the Clean Air Act (Title 40 Code of Federal Regulations (CFR) section 401.15; 40 CFR 61.01; 7/1/88). Vinyl chloride concentration in exhaust from vinyl chloride manufacturing or purification plants is not to exceed 10 ppm (40 CFR 61.65 (a); 7/1/89).

Water: Vinyl chloride has been designated a toxic water pollutant by the

EPA under section 307(a)(1) of the Clean Water Act (40 CFR 401.15; 7/1/88). Under the Safe Drinking Water Act the EPA has established a Maximum Concentration Limit (MCL) of 2 ppb (0.002 mg/l) (40 CFR 141.61; 7/1/88). The acute one day health advisory for vinyl chloride ingestion for a 10 kg child ingesting 1 liter of water per day is 3 mg/day[83]. A concentration of 0.15 ppb in drinking water will result in a 10^{-6} risk for a 70 kg adult ingesting 2 liters per day for a lifetime[83]. The California Department of Health Services (DOHS) action Maximum Concentration Level is 0.5 ppb[83].

The use of vinyl chloride in all pesticide products, as inert or active ingredient, has been cancelled or suspended[9]. The FDA has also banned the use of vinyl chloride as an aerosol propellant, and eliminated its use in drug products[84]. The FDA has also alerted food manufacturers of the need to monitor packaging material containing vinyl chloride and has proposed limiting the vinyl chloride monomer in packaging to 5-50 ppm[8].

The reportable quantity for vinyl chloride release is 1 lb./0.454 kg or more (54 FR 33419; 8/14/89). Vinyl chloride is subject to management as a hazardous waste under RCRA regulations and corresponding state regulations once it becomes a waste (40 CFR 261.33). Any residue, or contaminated soil, water or debris containing the released vinyl chloride is also considered hazardous waste (40 CFR 261.3(b)).

The U.S. EPA, Region IX has promulgated a tiered action level scheme to protect human health surrounding a California land fill. This scheme considered very young children, especially neonates, to be unusually sensitive to the carcinogenic action of vinyle chloride.

0.2 ppbv: Long term in-home exposures should be below this level in order to provide sufficient protection from unreasonable excess cancer risks. If indoor vinyl chloride levels exceed 0.2 ppbv, permanent action should be taken to reduce them to below this level.

0.2 - 10 ppbv: In the event indoor vinyl chloride levels are found within this range, permanent remedial action should be taken to bring levels below 0.2 ppbv. This action should be instituted and its effectiveness confirmed wtihin sixty (60) days.

10-100 ppbv: In the event indoor vinyl chloride levels are found within this range, temporary corrective action should be taken to bring levels below 10 ppbv. This tempeorary actoion should then be followed by permanent remedial action as specified for the 0.2 - 10 ppbv range. Temporary action should be instituted and ites effectiveness confirmed within twelve (12) days[86].

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Table 1. Acute Lethal Concentration Values in Several Mammalian Species

Species	Concentration (ppm)
Guinea pig	LC 100 = 100,000
Rabbit	LC50 = 230 - 800
Mouse	LC50 = 117 - 500
Rat	LClo = 6,000

(reference: 13)

Table 2. Occupational Exposure:
Permissible and Recommended Worker Exposure Limits

ACGIH TLV:	**5 ppm**
STEL:	**10 ppm**
OSHA TWA:	**1 ppm**
PEL:	**5 ppm**
NIOSH:	**0 ppm**

(ref: 8,85)

TOXICOLOGY BRIEF

CHLOROFORM

Synonyms:	Methane Trichloride, Formyl Trichloride, Methyl Trichloride, Trichloromehane, Trichloroform,NCI-CO2686, R-20 refrigerant.
CAS No:	67-66-3
Boiling Point	61.2°C
Color:	colorless
Conversion Factor:	1 ppm = 4.86 mg/m^3
Flammable Limits:	not flammable
Henry's Law Constant	3.67 x 10^{-3} (atm-m^3/mol)
Ionization Potential:	11.42 eV
Melting Point:	-63.5°C
Molecular Formula:	$CHCl_3$
Molecular Weight	119
Odor:	characteristic ethereal odor with a sweetish taste
Threshold:	85 ppm (air)
K_{oc}:	31 (ml/g)
Log K_{ow}:	1.97
Solubility:	miscible with alcohol, ether, benzene and other organic solvents. Slightly soluble in water
Specific Gravity:	1.498
Vapor Density:	4.12 (air = 1)
Vapor Pressure	1.97 x 10^2 mm Hg @ 25°C
Viscosity:	5.63 millipoise @ 20°C
Water Solubility:	8200 mg/l @ 20°C

(Ref: EPA, 1986; Hawley, 1987; Sax and Lewis, 1989)

GENERAL DATA

Historically, chloroform was used in medicine as a stimulant, taken internally, and as an inhalant in cases of asthma. In 1847 its anesthetic properties were discovered and it was used extensively in surgical procedures. Today, the primary use of the chloroform produced in the United States is as a refrigerant and aerosol propellant and in the synthesis of fluorinated resins (Sittig, 1981). It also has been used as an industrial solvent in the extraction and purification of penicillin and other pharmaceuticals, as a heat transfer medium in fire extinguishers (with carbon tetrachloride), as a pesticide and as an intermediate in the preparation of pesticides and dyes (Hawley, 1981). In the past, chloroform was used in the formulation of cough syrups, tooth pastes, linaments, and toothache preparations, but these uses and its use as an anesthetic were banned by the FDA in 1976 when it was found to be carcinogenic in mice.

FATE AND TRANSPORT

Chloroform has many potential ways of entering the environment because of its use as an industrial solvent, extract, and chemical intermediate and also because it is indirectly produced during the chlorination of drinking water, municipal sewage, and cooling water. Releases from industrail sources are primarily to the atmosphere where it may be transported long distances and will photodegrade with a half-life of 80 days (U.S. EPA, 1982). Some of the chloroform can return to the earth in precipitation. Because chloroform is poorly adsorbed by soil, especially soil with low organic carbon content, and is not biodegradable in water, spills or releases on land may leach into the ground water where it may reside for long periods of time (U.S. EPA, 1984).

TOXICITY DATA

Human Toxicology

Toxic effects include local irritation, gastrointestinal irritation, central nervous system depression, cardiac arrhythmia, ventricular tachycardia and bradycardia. The principal hazard from chloroform exposure is damage to the liver and kidney.

Acute dermal exposure to chloroform results in local irritation and inflammation. Exposure to the eye causes burning, tearing and reddening of the conjuctiva. Chloroform is more irritating to the skin and eyes than most chlorinated solvents. Ingestion of chloroform is followed immediately by severe burning in the mouth and throat, pain in the chest and abdomen, and vomiting. Alcoholics and persons with nutritional deficiencies are at a significantly higher risk to liver injury (Grayson and Eckroth, 1981).

Exposure to high concentrations of chloroform results in narcosis and anesthesia. Central nervous system depression is the most outstanding effect following acute exposure. At preanesthetic concentrations, humans have experienced headaches, nausea, vomiting, fatigue, dizziness, and excitation, which then leads to narcosis. High concentrations may result in cardiac sensitization. Chloroform exposure has been fatal to humans. Rapid death may occur because of cardiac arrest, and delayed death may occur because of liver and kidney damage (HSDB, 1987).

Pharmacokinetics

Humans may be exposed to chloroform by inhalation, ingestion or skin contact. Human bioassays and animal experiments have shown that chloroform is rapidly absorbed (100% from the gastrointestinal tract, 49-77% via inhalation), distributed throughout body fat and tissues, and excreted (U.S. EPA, 1980).

Significant Animal Studies

Repeated exposure to subnarcotic levels of chloroform can cause liver and kidney toxicity (Klassen et al., 1986). Torkelson et al. (1976) exposed rabbits, rats, guinea pigs and dogs to 25, 50 or 85 ppm of chloroform for seven hours per day, five days a week for six months. Histopathological evaluation revealed cloudy swelling of the kidneys and central lobular granular degeneration and neurosis of the liver. The effects at 25 ppm were slight and reversible, and rats exposed for 1, 2 or 4 hours/day were not adversely affected.

Reproductive Toxicity

Inhalation of chloroform for 7 hours/day on days 6-15 of gestation at dose levels of 30, 100, 300 ppm produced teratogenic effects in Sprague-Dawley rats (Schwetz et al., 1974). The authors noted a decrease in conception rate and a high incidence of fetal resorption at 300 ppm, retarded fetal development at all dose levels, decreased fetal body measurements at 30 and 300 ppm, and a low incidence of acaudate fetuses with imperforated anuses at 100 ppm. They concluded that chloroform was highly embryotoxic rather than highly teratogenic. Thompson et al. (1974) found that ingestion of chloroform caused fetotoxicity at a level which produced severe maternal toxicity.

Carcinogenicity

Animal experimentation has provided some evidence that chloroform is a carcinogen. In a study by the National Cancer Institute (1976), B6C3F1 male and female mice were given oral doses of chloroform at 138 or 277 mg/kg and 238 or 477 mg/kg, respectively, five times a week for 78 weeks. Animals were sacrificed at 92-93 weeks. Hepatocellular carcinomas were observed in all groups. Modular hyperplasia was seen in low-dosed males without carcinomas. In a separate portion of the same study using Osborne-Mendel rats, chloroform administered at 90 or 180 mg/kg in males and 100 or 200 mg/kg in females five times a week for 78 weeks produced kidney epithelial tumors. In high-dosed males, tumor occurrence was 25%, whereas in low-dosed males, the occurrence was 8%. Females had benign thyroid tumors.

Although human data regarding carcinogenicity are limited, animal evidence is sufficient to classify chloroform as an animal carcinogen. The Carcinogen Assessment Group of the U.S. EPA has classified chloroform as a Group "B2" compound, a probable human carcinogen.

REGULATIONS AND STANDARDS

The National Primary Drinking Water Regulation for total trihalomethanes (including chloroform) is 100 ug/L (U.S. EPA, 1990w). This concentration is an enforceable drinking water regulation that was first established under the Safe Drinking Water Act. It is protective of public health to the extent feasible.

The current Threshold Limit Value (TLV) for chloroform is 10 ppm (ACGIH, 2000). The TLVs are developed by the American Conference of Governmental Industrial Hygienists for use in the practice of industrial hygiene. TLVs are eight hour time-weighted average concentrations. They are intended to be interpreted and used by trained industrial hygienists. They are not developed for use as legal standards and they do not apply to situations outside of the workplace.

There is no OSHA Permissible Exposure Limit (PEL) for chloroform but there is a Ceiling value of 50 ppm. NIOSH considers chloroform an occupational carcinogen and recommends that exposures be kept as low as feasible. The recommended Short Term Exposure Level (STEL) to chloroform by NIOSH is 2 ppm (NIOSH, 2001).

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TOXICOLOGY BRIEF

1,1-DICHLOROETHYLENE

Synonyms:	Vinylidene Chloride; 1-1-DCE; Vinylidene Dichloride
CAS No:	75-35-4
Color:	colorless liquid
Boiling Point:	31.5°C (89°F)
Conversion Factor:	1 ppm = 4.0 mg/m^3
Flammability:	
Flash point:	-2°F
LEL:	6.5%
UEL:	15.5%
Henry's Law Constant	0.034 atm-m^3/mole
log K_{oc}:	150
log K_{ow}:	2.13
Molecular Formula:	$C_2H_2Cl_2$
Molecular Weight:	96.95
Melting Point:	-122.2°C
Odor:	mild, sweet, chloroform-like
Threshold:	500 - 1000 ppm
Specific Gravity:	1.21 (water =1)
Vapor Density	3.25 (air =1)
Vapor Pressure:	591 mm Hg @ 25°C
Viscosity:	0.358 cP @20°C
Water Solubility:	2250 mg/l @ 20°C

GENERAL DATA

1,1-Dichloroethylene (1,1-DCE) is a highly reactive, flammable, clear, colorless liquid that can produce complex peroxides in the absence of chemical inhibitors. 1,1-DCE and its peroxides are violently explosive and produce formaldehyde, phosgene, and hydrochloric acid as decomposition products. 1,1-DCE can form explosive peroxides upon exposure to air and reacts vigorously with oxidizing materials (Sax and Lewis, 1989).

1,1-DCE is an intermediate in the synthesis of methylchloroform and in the production of barrier coating plastics such as polyvinylidene chloride copolymers (PVDCs). Polymers with high 1,1-DCE content, such as Saran Wrap, are commonly used for food packaging. The interior coatings for storage tanks and steel pipes and structures are often made of 1,1-DCE polymers (EPA, 1980). Such uses increase the likelihood that the substance will be found in the environment. Fishbein (1976) points out, however, that there are no data that document the extent to which untreated monomers of 1,1-DCE might migrate into food or water that comes in contact with the above-described plastics and coatings of discarded materials.

FATE AND TRANSPORT

Little information is available on the environmental fate and transport of 1,1-DCE (EPA, 1987). It is known, however, that because of 1,1-DCE's high vapor pressure (591 mm Hg 25°C),

volatilization is a major transport mechanism. 1,1-DCE is expected to volatilize rapidly when released in surface waters and degrades in a matter of hours when released into the atmosphere (EPA, 1987). In water, 1,1-DCE is chemically stable. The half-life is estimated to be eight weeks (Pearson and McConnell, 1975). 1,1-DCE is mobile in soils and is expected to migrate with the groundwater (EPA, 1987). 1,1-DCE is very soluble in water (2250 mg/L @ 77°F) and has a correspondingly low octanol water partition coefficient (log K_{ow}) of 1.84. 1,1-DCE would not be expected to accumulate in animals because it is not very lipid-soluble.

TOXICITY DATA

Human Toxicological Profile

Relatively little information is available on human toxicity to 1,1-DCE exposure. One epidemiological study (Ott et al., 1976) examined an occupationally exposed cohort of 138 workers (who had no concomitant exposures to other chemical solvents) for adverse health effects associated with exposure to 1,1-DCE. No significant findings were reported, however this study employed an insufficient sample size. NIOSH (1979) reports that liver dysfunction, headaches, vision problems, weakness, fatigue, and neurological sensory disturbances are some of the reported effects of occupational exposure to 1,1-DCE.

Pharmacokinetics

Pharmacokinetics data for absorption and excretion of 1,1-DCE are scarce. McKenna et al. (1978), report that 1,1-DCE given by gavage is completely absorbed, since virtually all of a single dose is excreted within 72 hours. Rat and mouse studies have revealed that rapid organ distribution to the kidney, spleen, liver, brain, and heart occurs (Jaeger et al., 1977). Subcellular distribution of 1,1-DCE includes compartmentalization in the microsomes, mitochondria, and cytosol.

It appears that the intermediate epoxide metabolites of 1,1-DCE are more reactive and more toxic than the compound itself. Pre-treatment of mice and rats with various epoxides (e.g., 2,3-epoxypropan-1-ol, styrene oxide) has been shown to interfere with the full metabolism of the intermediate epoxides and to exacerbate the toxic effects of 1,1-DCE (Anderson et al., 1977). In another study (Short et al., 1977), the hepatotoxic and nephrotoxic effects due to 1,1-DCE were mitigated when mice and rats were pretreated with disulfiram, an aldehyde dehydrogenase inhibitor.

Animal Toxicology and Significant Studies

The acute lethal oral dose for rats is 200 mg/kg (Short et al., 1977), while the acute lethal inhaled dose for mice is 98 ppm with a 22-hour exposure period (Anderson et al., 1977). Acute toxic effects include central nervous system depression at high concentrations and liver and kidney damage at lower concentrations (Proctor et al., 1988).

Reproductive Toxicity

Teratogenic effects have been reported in rats and rabbits exposed to 1,1-DCE via inhalation (Murray et al., 1979). Dosages of 20, 80 and 160 ppm were administered. Skeletal abnormalities were observed at the two higher concentrations in rats while only the higher dose caused "several

minor skeletal variations in rabbits." The authors observed no adverse effects on embryonal or fetal development in the inhalation study at 20 ppm in the rat and 80 ppm in the rabbit. Nitschke et al. (1983) reported that reproduction in rats was not affected over three generations after exposure to 1,1-DCE at concentrations of 0, 50, 100, or 200 ppm in their drinking water.

Mutagenicity

Greim et al. (1975) reported that 1,1-DCE was mutagenic to E. coli at a concentration of 2.5 M in the presence of microsomal activation. Short et al. (1977) and Anderson et al. (1977) reported that, using the dominant lethal assay, mutagenic effects were not observed in mammalian assay systems after exposure to 1,1-DCE at 55 ppm for 6 hr/day for 11 weeks to 10 to 50 ppm for 6 hr/day for 5 days, respectively. Reitz et al. (1980) reported that in rats and mice exposed to 10 or 50 ppm of inhaled 1,1-DCE for 6 hours, 1,1-DCE binds slightly with the DNA in the liver and kidneys but causes massive tissue damage. There is sufficient evidence to state that 1,1-DCE is mutagenic (IARC, 1979).

Carcinogenicity

Eighteen animal studies have been reported concerning the carcinogenicity of 1,1-DCE (eleven inhalation, five oral, one dermal, and one subcutaneous exposure). These studies were not designed for maximum sensitivity to detect carcinogenic effects although 3 out of the five oral studies, were for lifetime exposures. Maltoni et al. (1985) was the only reported positive carcinogenic response (IRIS, 1991).

Maltoni et al. (1985) exposed both sexes of Swiss mice by inhalation to 10 and 25 ppm (maximum tolerated dose) for 4-5 days per week for 12 months and found a significant increase in kidney adenocarcinoma. Treatment was for only 50% of lifetime (12 months) and only two dose groups provided data suitable for modeling. Tumors were not observed in either the two control groups or the one 10 ppm treatment group, although both 25 ppm treatment groups developed tumors. According to IRIS (1991), within each dose pair (control and 25 ppm groups), there were no statistically significant differences between tumor incidences. These groups were combined for purposes of modeling. The 10 ppm group does not appear to have been included in the modeling, and its exclusion would cause the slope to be higher and the potency estimate to be more conservative. The data quality supporting the finding that 1,1-DCE is a carcinogen is weak, which resulted in U.S. EPA's classification of 1,1-DCE as a possible human carcinogen (Group C) as opposed to a probable human or known human carcinogen (Group B and A). From this study, an inhalation cancer slope factor of 1.2 $(mg/kg/day)^{-1}$ was derived.

The oral cancer slope factor of 6.0×10^{-1} $(mg/kg/day)^{-1}$ was derived from the highest of four slope factors derived in two studies. Neither the studies produced statistically significant increases in tumor incidences attributable to oral exposure to 1,1-DCE.

REGULATIONS AND STANDARDS

The American Conference of Governmental Industrial Hygienists (ACGIH, 2000) recommends a TWA-TLV: 5 ppm (20 mg/m^3). OSHA does not list a PEL. NIOSH recognizes 1,1 DCE as an occupational carcinogen and recommends that exposures be kept as low as feasible (NIOSH, 2001).

The non-carcinogenic risk estimates for 1,1-DCE have been summarized from the U.S. EPA Integrated Risk Information System (IRIS, 1991) chemical database. The oral reference dose (RfD) is based on the lowest observable adverse effect level (LOAEL) derived from a chronic oral rat bioassay (drinking water exposure) by Quast et al. (1983). An uncertainty factor of 1000 was employed to derive an oral RfD of 9.0×10^{-3} mg/kg/day. The endpoint effect in question was liver damage. CARB reports an oral RfD of 9.0E-3 x 10-1 mg/kg/day; from this, CAPCOA derived an inhalation RfD (RfC) of 3.2E+1 mg/m^3 (CAPCOA, 1991).

IRIS (1998) reports an oral cancer slope factor (CSF) of 6.0×10^{-1} (mg/kg/day)$^{-1}$ based upon gavage studies and an inhalation CSF of 1.2 (mg/kg/day)$^{-1}$ based upon an inhalation study. The U.S. EPA classified 1,1-DCE as a Group C carcinogen (possible human carcinogen) based upon the weak evidence supporting a causal relationship between 1,1-DCE and its ability to cause cancer in laboratory animals following lifetime exposure. Based upon this weak causal relationship, Class C carcinogens are not typically included in risk assessment activities. For purposes of establishing under RCRA and CERCLA, 1,1-DCE is not viewed as a carcinogen. The current Maximum Contaminant Level for drinking water for 1,1-DCE is set by U.S. EPA at 7.0 mg/L (IRIS, 1991). CAPCOA, 1991, does not list a slope factor for 1,1-DCE by either inhalation or ingestion routes of exposure.

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Appendix D
Ambient Air Monitoring Form

Ambient Air Monitoring Form

Project Name: Project Number: Date:

Document Routing	
SSO	Retain copy in site health & safety file.

1. Work Information

ERM Representative:	
Work Crew Members & Employers:	

2. Monitoring Details

Time	Ambient Air Monitoring Location	Results

3. Completion

Name: _____

Signature: _____

Appendix E
Subsurface Clearance Checklist

SUBSURFACE CLEARANCE PROCEDURE **FIELD** CHECKLIST

(Use this sheet to document basic field elements of SSC, and keep with project information)

Site Name/Project No.: _____

Walkover Date: _____

By (ERM/Client Names): _____

(ERM-MANAGED SUBSURFACE CLEARANCE ACTIVITIES)	**Yes**	**No**	**N/A**	Comments
Preparation Tasks	Observed?			
1. The potential for unexploded ordnance (UXO) has been assessed and a UXO survey performed	☐	☐	☐	
2. A site walk-over was conducted and above-ground indicators of underground utilities noted or mapped.	☐	☐	☐	
• Telephone Lines	☐	☐	☐	
• Data lines/cable trench	☐	☐	☐	
• Gas pipes/storage tanks	☐	☐	☐	
• Potable water pipes/fire water (sprinklers) pipes and hydrant lines	☐	☐	☐	
• Sewer lines (storm water/process water)	☐	☐	☐	
• Steam lines (district) and heating lines	☐	☐	☐	
• Fuel oil lines/storage tanks (UST), incl. tankfield fill ports, observation wells, vent stacks	☐	☐	☐	
• Lighting (street and traffic)	☐	☐	☐	
• Other underground utilities	☐	☐	☐	
• Hydrants	☐	☐	☐	
• Non-native soil	☐	☐	☐	
• Warning Tape	☐	☐	☐	
• Manholes	☐	☐	☐	
3. "Critical zone" decisions	☐	☐	☐	
• A mark has been placed on the map to limit surface disturbance within 10 feet of:	☐	☐	☐	
o Tanks, dispenser islands	☐	☐	☐	
o Piping manifolds	☐	☐	☐	
o Pumps/pump galleries	☐	☐	☐	
o Loading racks	☐	☐	☐	
o Process equipment	☐	☐	☐	
o On- or below-grade transformers	☐	☐	☐	
o Compressors				
o Underground chemical lines and high voltage utilities	☐	☐	☐	

Form completed by: _____ _____

Name Date

Appendix F
Daily Safety Meeting Form

ERM Daily Tailgate Safety Meeting Form

Date: _____ Time: _____ Project No.: _____

Project Name/Location: _____

Scope of Work: _____

Work Duration: _____

Subcontractors / Third Parties: _____

Safety Meeting Core Topics – All Site Workers *and* Visitors – DAILY & AS CONDITIONS CHANGE:

- ☐ What is the scope of work to be performed?
- ☐ What PPE is required in order to enter the work zone?
- ☐ What are the potential hazards associated with: Tools/equipment/moving parts? Body use and positioning / heavy lifting? Work environment (traffic, tripping hazards, poor housekeeping, overhead lines, biological hazards, etc)? Chemical exposure?
- ☐ What are the potential impacts of planned activities to: Site visitors? Nearby workers? Nearby residents? Client Property? Passers-by?
- ☐ What's the worst that could happen if something goes wrong?
- ☐ What steps will be taken to remove or reduce the risks from potential hazards?
- ☐ Is everyone aware that they are empowered to stop work if something is questionable or unsafe?

Safety Meeting Core Topics – All Site Workers *and* Visitors – FIRST VISIT & WEEKLY AT A MINIMUM:

- ☐ What happens if there is an emergency (injury, illness, spill/release, fire)? Who do you contact in case of emergency? If working at an active facility, how will you be alerted of an emergency? Where is the designated evacuation and assembly area? What is the process for reporting incidents?
- ☐ Who do you contact if there is a non-emergency injury or first aid, property damage, or near miss? Who do you contact if you have questions, or before deviating from written work scope / procedures?
- ☐ When and how will you communicate with ERM PM? ERM H&S Coordinator? Client or Site Contact? How will you contact Emergency Response Personnel?
- ☐ Where is safety equipment located (fire extinguisher, first aid kit, eyewash, safety shower)? Is equipment in good working condition? When were fire extinguishers last inspected?
- ☐ Where are nearest sanitary facilities? Nearest designated eating / smoking areas?

Additional Topics – Site Workers Only -– DAILY & AS CONDITIONS CHANGE:

- ☐ Are any work permits required? Are permits completed and posted at job site in plain view of workers?
- ☐ Have all excavation / borehole locations been cleared of underground utilities/structures, in accordance with ERM and client-specific subsurface clearance procedures?
- ☐ Has the work zone been defined and barricaded? How are you controlling entry into and out of the work zone? Has a contaminant reduction zone been defined?
- ☐ Have all tools / equipment / vehicles been inspected today to ensure safe operating condition?
- ☐ Will a follow-up safety meeting be conducted after lunch?
- ☐ Has anything unexpected or out-of-the-ordinary occurred on this job recently? Anything that you would do over again if you could? Are any of these near misses that others can learn from?

Additional Topics – Site Workers Only -– FIRST VISIT / FIRST DAY OF NEW MAJOR JOB PHASE:

- ☐ Has the HASP been reviewed and signed by all workers? Have subcontractor HASPs (if applicable) been reviewed, and are they consistent with ERM HASP?
- ☐ Task Hazard Analysis (THA) or equivalent hazard evaluation completed for all planned tasks? Have THAs been reviewed and hazards identified / discussed? Do THAs accurately reflect how work is being performed? Do THAs contain detailed, measurable actions to remove or reduce risks? Were THAs developed with input from all site workers?
- ☐ What kinds of wastes will be generated? How are wastes being stored, managed, profiled, and disposed? [NO SIGNING OF HAZARDOUS WASTE MANIFESTS!]
- ☐ How often are worker breathing zones being monitored (if applicable), and for what constituents? When were air monitoring instruments last calibrated? What would trigger the donning of APRs?

Tailgate Safety Meeting Attendees – All Site Workers:

Name: Company: Signature:

Visitors to Job Site:

Name: Company: Signature:

Notes / Additional Topics Discussed:

Appendix G
ERM Incident Form

Incident Investigation Form

FOR ERM MANAGEMENT INTERNAL USE ONLY, CONFIDENTIAL - WITHOUT PREJUDICE REPORT

Instructions: Aim to complete **Part 1 of this form within 24 hours** after the incident and complete **Part 2 within 3 working days** after the incident. In addition to the Project Manager and OpCo Health and Safety Coordinator, who are primarily involved with the investigation, please ensure that the following individuals are made aware of the incident at least verbally within 24 hours and receive the completed incident form as soon as it is completed: **Branch Manager; Corporate H&S Director, OpCo President, and Regional CEO**. Based on the requirements of the company's claims reporting procedure (which shall be updated from time to time), if necessary, the OpCo President will notify the company's Legal Department. The OpCo H&S Coordinator should keep paper or electronic copies of these reports. If a piece of information does not apply, put N/A in the block.

I. INJURY AND ILLNESS DATA AND SUMMARY

Date and time of incident Date: Time:	Location of incident (Name and address)	
Time injured employee started work on day of incident	Weather conditions	
Reported by	Date reported	List any witnesses
Project Number	Project Manager	Principal-in-Charge
Injured employee's name	Injured employee's department or practice area	
Injured sub-contractor's name	Injured sub-contractor's employer	
Injured person's sex Male ☐ Female ☐	Injured employee's date of hire at ERM	
Type of Incident (check one) ☐ First aid/minor injury ☐ All other injuries ☐ Vehicle accident ☐ Property damage ☐ Near miss		
What activity/task was taking place just prior to the incident? (Describe the activity/task as well as tools, equipment and material involved that set the stage for the incident. What was the worker doing?)		

What changed about the situation or task to cause the incident? How did the incident happen? (Describe in detail the incident.)	
If the incident involved an injury, describe it. (e.g., cut to left ring finger, sprained right ankle, snake bite to left shin, pulled muscles in the lower back)	
Immediate actions taken (Describe actions taken and by whom immediately after the incident occurred.)	
What object or substance directly harmed the employee? (Examples, concrete floor, chlorine, H2S, manhole cover. If this question does not apply to the incident, write N/A.)	
If medical treatment was given away from worksite, state name and mailing address of both the facility and treating health care professional.	
Was employee treated in an emergency room? Yes ☐ No ☐	Was employee hospitalized overnight as an in-patient? Yes ☐ No ☐
Additional Consequences of incident (Describe damage to property/equipment, consequences to other employees or community, schedule.)	
If the employee died, give date of death.	
Is the incident recordable/reportable under any governmental requirement? (To be completed by OpCo Health and Safety Coordinator) Yes ☐ No ☐ Name of person making determination	

How many photos of the scene were taken?		
(If completed manually) Please note the position of the injury on the diagram and sketch any other instructive diagrams here as well.		
Name of person completing form	Signature of person completely form	
Title of person completing form	Phone number of person completing form	Date form completed

Instructions: This side of the form will be completed as directed by the OpCo Health and Safety Coordinator

II. CAUSES AND PLANS TO PREVENT RECURRENCE

Actions leading to incident. (Check all that apply and explain.)

- ☐ Failure to observe warning
- ☐ Failure to use PPE
- ☐ Failure to warn
- ☐ Delayed discovery
- ☐ Procedure not followed
- ☐ Abuse/misuse of equipment
- ☐ Other

Conditions leading to incident. (Check all that apply and explain.)

- ☐ Temperature/weather
- ☐ Inadequate maintenance
- ☐ Nature (animal, insects, plants)
- ☐ Lack of PPE
- ☐ Lack of proper instructions
- ☐ Construction deficiencies
- ☐ Improper design/engineering
- ☐ Improper/defective tools/ equipment
- ☐ Other

Job factors leading to incident. (Check all that apply and explain.)

- ☐ Leadership/supervision
- ☐ Work practices
- ☐ Defective tools/equipment
- ☐ Inadequate communication
- ☐ Inadequate training
- ☐ Inadequate inspections
- ☐ Inadequate work procedures/practices
- ☐ Other

Personal factors leading to incident. (Check all that apply and explain.)

- ☐ Physical capability
- ☐ Physical stress/fatigue
- ☐ Mental stress
- ☐ Knowledge of task
- ☐ Employee skills
- ☐ Attention to details
- ☐ Other

Corrective Actions	Person responsible	Deadline	Date completed
1)	1)	1)	1)
2)	2)	2)	2)
3)	3)	3)	3)
4)	4)	4)	4)